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CONVERSION OF UNUTILISED ICE CREAM FROM PRODUCTION PROCESS INTO VALUE-ADDED PRODUCT

NUR SYAZWANI JAMALUDIN

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NUR SYAZWANI BINTI JAMALUDIN

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ABSTRACT

Driving innovation with integration in food has become so important nowadays for creating value and product differentiation. Innovated product created from left-over or unfinished food is a good alternative to throwing away food by-product. In this study, left-over ice cream post-selling or post-production process was reformulated with other ingredients to produce bakery product i.e. cake. Two stages of production were conducted which is the production of ice cream and the production of cakes. During the production of ice cream, the viscosity of ice cream mix (after 'ageing' process) and melted left-over ice cream was determined to compare the value of viscosity for both condition. The result obtained shows that the value of viscosity of melted left-over ice cream is higher than the viscosity of ice cream mix. For production of cakes, four suggested formulation which varied the amount of eggs were used, including melted left-over ice cream and instant cake mix as the main ingredient. The physical qualities of the samples were investigated, and sensory evaluation was also conducted. Conventional cake using instant cake mix without the addition of melted left-over ice cream was used as a control sample in the production of cakes. Cake produced from melted left-over ice cream using three eggs (sample A) had the highest moisture content among all samples which was 39.09%. Control sample shows the highest specific volume (4.07 cm^3/g) which indicates high amount of air remain after baking. All sample shows positives symmetry index which has a good expansion except for cake produced from melted left-over ice cream with no egg (sample D). The firmness value of cake produced from melted left-over ice cream with no egg (sample D) significantly lower among those cakes produced. Cake produced using melted left-over ice cream which contained two eggs (Sample B) had the highest values

of springiness which was 0.94 mm. A plot of chewiness as a function of firmness with R^2 value of 0.7809 confirms the positive correlation between firmness and chewiness. From the sensory evaluation conducted, the cake produced from melted left-over ice cream using three eggs (sample A) scored the highest mark for colour, odour, sweetness, taste and overall acceptability among the formulated cakes. The results suggested that using melted left-over ice cream as the base ingredient for cake making would tremendously help in solving food waste created by the by-product from ice cream business and turn it into profit.

ABSTRAK

Pemanduan inovasi bersama integrasi di dalam makanan menjadi sesuatu yang sangat penting pada masa ini untuk mencipta pembezaan nilai dan produk. Innovasi produk yang telah direka daripada makanan yang tersisa adalah alternatif yang bagus kepada pembuangan makanan daripada lebihan produk. Di dalam penyelidikan ini, ais krim yang tersisa daripada proses pasca pengeluaran telah dirumus semula bersama bahan yang lain untuk menghasilkan produk roti sebagai contoh kek. Dua tahap penghasilan telah dijalankan dimana ianya penghasilan ais krim dan penghasilan kek. Semasa penghasilan ais krim, kelikatan campuran ais krim (selepas proses 'ageing') dan ais krim cair telah dikenalpasti untuk membandingkan nilai kelikatan kedua-dua konsidi tersebut. Daripada hasil yang didapati, nilai kelikatan ais krim cair lebih tinggi berbanding kelikatan campuran ais krim. Untuk penghasilan kek, empat formulasi telah di cadangkan di mana kepelbagaian jumlah telur telah digunakan termasuk lebihan ais krim yang telah cair dan kek campuran segera sebagai bahan utama. Kualiti fizikal sampel telah dikenal pasti dan penilaian deria juga telah di jalankan. Kek konvensional menggunakan kek campuran segera tanpa penambahan ais krim cair telah digunakan sebagai sampel kawalan di dalam penyelidikan ini. Kek yang di perbuat daripada ais krim cair menggunakan tiga biji telur (sampel A) mempunyai kandungan kelembapan tertinggi di antara kesemua sampel iaitu 39.09%. Sampel kawalan menunjukkan spesifik isipadu tertinggi (4.07 cm^3/g) dimana ia membuktikan jumlah udara yang tinggi yang masih kekal selepas dibakar. Kesemua sampel memperlihatkan simetrik indeks yang positif dimana mereka mempunyai pengembangan yang bagus kecuali kek diperbuat daripada aiskrim cair yang tidak menggunakan telur (sampel D). jumlah kekerasan kek diperbuat daripada aiskrim cair

yang tidak menggunakan telur (sampel D) telah menunjukan nilai yang terendah dengan ketara di antara kek yang dihasilkan. Kek yang dihasilkan menggunakan asikrim cair di mana ia menggunakan dua biji telur (sampel B) mempunyai nilai kekenyalan paling tinggi iaitu 0.94 mm. plot daya kunyah sebagai fungsi kepada kekenyalan menunjukkan nilai R^2 iaitu 0.7809 mengesahkan hubungan yang positif di antara mereka. daripada penilaian deria yang telah dijalankan, kek diperbuat dariada ais krim cair menggunakan tiga biji telur (sampel A) menskor markah tertinggi untuk warna, bau, kemanisan, rasa dan juga penerimaan secara keseluruhan di antara kek yang telah di formulasi. hasil kajian mencadangkan bahawa menggunakan ais krim cair sebagai bahan asas untuk pembuatan kek boleh menolong secara luar biasa di dalam menyelesaikan isu sisa makanan yang telah di hasilkan daripada sisa produk daripada perniagaan ais krim dan mengubah nya kepada keuntungan.

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CHAPTER 1 : INTRODUCTION

In this chapter, an overview of the project conducted which consist of the background, problem statement and objectives was described

1.1 Background of ice cream and left-over ice cream

Ice cream is an enormously popular food. The term "ice cream" in its broadest sense covers a wide range of different types of frozen dessert. The main ones are dairy ice cream, non-dairy ice cream, gelato, frozen yoghurt, milk ice, sorbet, sherbet, water ice and fruit ice (Clarke, 2012). What these all have in common is that they are sweetened, flavoured, contain ice and, unlike any other frozen food, and are normally eaten in the frozen state.

Today ice cream is found in almost any restaurant, or corner store, and is recognized globally as the perfect summer treat. Textural attributes of ice are the key factors determining the market success of the product. Many industries manufacture ice cream at global level such as General mills, Unilever and Nestle. In 2010, total production of ice cream was 16.3 billion liters in whole world and Pasific Asia was the top producing that was 31% of total production (Marshall et.al., 2012).

Ice cream is a dairy aerated dessert that is frozen prior to consumption. It is a microcrystalline network of liquid and solid phases. It contains air cells entrapped in liquid phase and various other components like proteins, fat globules, stabilizers, sugar, soluble and insoluble salt are present in this phase. It is a complex physicochemical and colloidal system consisting on many complex ingredients that affect ice cream structure, texture and palatability.

Generally, the main ingredient of ice cream are milk fat, milk solid non-fat (MSNF), sweetener that usually a combination of sucrose and glucose, stabilizers, emulsifier and water. All of this ingredients have its own function in production of ice cream. The combination of this ingredients can make a perfect taste, texture and flavour on the ice cream depends on its composition.

Typical ice cream comprised of approximately 30% water, 50% air, 5% fat and 15% matrix (sugar solution) by volume (Clarke, 2004). Ice cream can be categorized into three different classes which are premium, standard and economy. The grade of ice cream depends on the amount of milk fat content. Generally, ice creams containing more than 12% are recognized as premium level. Milk fat is importance in qualifying ice cream because it is closely related with the flavour and texture of the ice cream (Li et al., 1997). Premium ice cream usually has relatively high amount of milk fat and low amount of air while the economy ice cream uses vegetable fat and contains more air.

Other than that, ice cream known as one of the food material that is very sensitive to temperature. When the ice cream is exposed to the surrounding (warm environment), the structure of ice cream starts to melt and collapse including some of the small ice crystal and air bubbles.

The meltdown process of ice cream can be divided into three phases which are the lag phase, the fast-melting phase, and the stationary phase. In the lag phase, heat penetrates into the ice cream, and ice crystals begin melting and dilute the serum phase, which reduces its viscosity. With reducing viscosity and increasing flowability of diluted serum phase, ice cream meltdown reaches the second stage which is fast-melting phase. At this stage, the ice cream starts dripping through the wire mesh by the driving force of gravity to reach the maximum meltdown rate (Goff & Hartel, 2013). During fast-melting phase is the ice cream collapses at a rate and to an extent, depending on the remaining structures including air cells and fat clusters or globules. If there are numerous fat clusters around the air cells, they collide with each other and jam as the serum drains to form a three-dimensional network with air cells, so that meltdown gradually slows and comes to the stationary phase. If there are few fat clusters, ice cream is able to totally drip through without leaving foam on the mesh.

The quality of ice cream depends on its microstructure whereby the small ice crystals and air bubbles give the ice cream a smooth and soft texture. If the ice crystals are too large, the ice cream becomes gritty and unpleasant to eat. Figure below is the example of the changes of microstructure of ice crystal when the ice cream exposes to high temperature even at below its melting point (Chris, 2003).

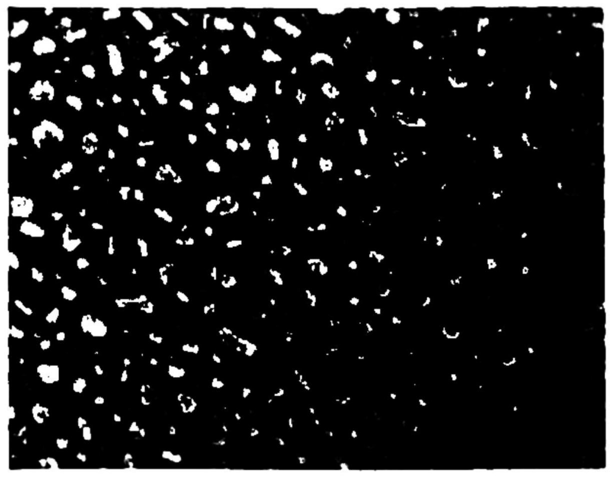

Figure 1.1: Ice crystal at -10°C

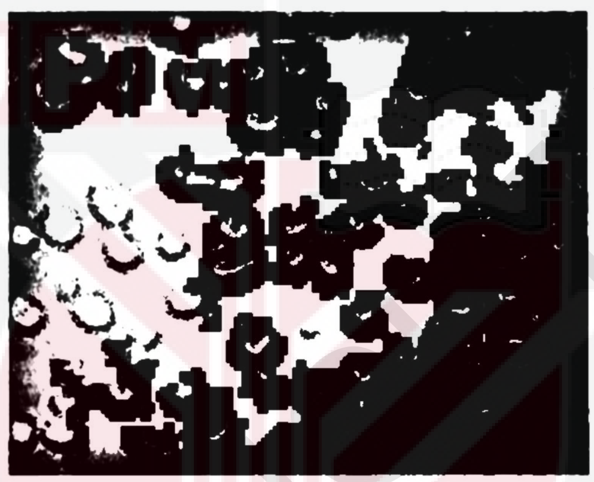

Figure 1.2: Ice crystal warmed to -7°C

The situation of melted left-over ice cream is commonly occurred in the ice cream business where there are days when the retailer are unable to finish the ice cream inside the machine. The left-over ice cream normally would be kept inside the chiller to be reused for the next production or thrown away into the waste disposal bin. However, reusing the left-over ice cream for the next production may lead to unpleasant taste of ice cream which may affect the shop's reputation.

Regarding to this issue, melted left-over ice cream seems has a huge potential to be converted into bakery product, which is cake. This study is important because there were no research on the treatment of the left-over ice cream has been conducted. Besides, this study would be beneficial to any ice cream business to expand their ice cream-based product by innovatively reusing the by-product or left-over off the processing or selling stage. After getting the desired result, the cake produced from left-over ice cream will be analyze by determining the physical, textural and sensorial properties of the cakes.

1.2 Problem Statement

Left-over ice cream seems has a huge potential to be converted into bakery product such as cake, muffin and bread. Even though there is no available research study made on the treatment and handling method of left-over ice cream, the availability of various articles and online websites on how to creatively innovate the left-over ice cream into amazing food product are really helpful in understanding the handling of its by-product. However, these suggested applications usually practical for a small-scale ice cream business that would help them to generate profit from the conversion of left-over food or food waste into new food product.

The issue on left-over ice cream is rarely highlighted due to the small quantity of ice cream left and occurred in small-scale ice cream premises only. The left-over ice cream usually would produce unpleasant taste and texture. Besides, the left-over ice cream normally would be thrown away into the waste disposal bin instead of renovate them. In fact, high cost of Research and Development (R&D) also influenced the small-scale ice cream premises to innovate the left-over ice cream.

Therefore, this study was conducted to develop a value-added product which is cake, from left-over ice cream. Ice cream consists of ingredients that are similar to the ones in cake i.e. fat, protein, sugar, emulsifier, stabilizer and water. The melted ice cream cake needs further addition of emulsifier i.e. eggs to produce cakes of similar quality as the conventional cakes. The recipe used for making cakes from melted left-over ice cream was adapted from Brandie (2019). The ingredient used were instant cake mix, eggs and melted ice cream. The instant cake mix was used in this study in order to get the simplest cake made from melted left-over ice cream and that is convenient for everyone to do. Four suggested formulation were used in this study by varying the amount of eggs. The final product of cake made from left-over ice cream would be tested on the physical, textural and sensorial properties of cakes. It is assumed that the cake produced from left-over ice cream has a good texture and taste as well as it could minimize the wastage and reduce the environmental pollution.

1.3 Objectives

The main objective of this study is to develop a value-added product from left-over ice cream. To be more specific, the objectives of this study were:

i. To determine the viscosity of ice cream mix (after 'ageing' process) and melted left-over ice cream.

ii. To identify the physical, textural and sensorial qualities of cakes produced from left-over ice cream.

CHAPTER 2 : LITERATURE REVIEW

This chapter will be discussed about the literature review on ice cream in all view based on journals paper, review paper and website that can be referred.

2.1 Overview of ice cream

Ice cream can be defined as a smooth, sweet, cold dessert food prepared from a frozen mixture of milk products and flavourings, containing a minimum of 10% milk fat (Karaman et al., 2014). After pasteurisation, the mixture is homogenised and aged to improve the physical properties before freezing. Ice cream is a representative frozen dairy product that people of all ages enjoy because of its cooling effect in the mouth.

2.2 Ice cream mix ingredient

Ice cream mix is made up from seven main ingredients that are milk fat, milk solids not-fat (MSNF), sweeteners, stabilizers, flavourings, emulsifiers and water. Dairy and other ingredients used to supply these components are selected based on the finished product's cost, availability and quality. According to Goff and Hartel (2013), ice cream typically has more than 10% milk fat by legal definition and generally between 10% and as much as 16% fat in some premium ice creams, 9 to 12% of milk-solid-non-fat also known as serum solids which consist of proteins (caseins and whey proteins) and carbohydrates (lactose) found in milk, sweeteners or sweeting agents which has 12 to 16% that usually a combination of sucrose and glucose-based corn syrup sweeteners, 0.2 to 0.5% of stabilizers and emulsifiers, and 55 to 64% of waters which comes from milk or other ingredients. These percentages are by weight, either in the mix or in the frozen ice cream. For hard ice cream, there is formulation suggestion as the table below according to Goff & Hartel, 2013.

Table 2.1: Formulation suggestion for hard ice cream

	Percent (%)						
Milk fat	10	11	12	13	14	15	16
Milk solid non fat	11	11	10.5	10.5	10	10	9.5
Sucrose	10	10	12	14	14	15	15
Corn syrup solids	5	5	4	3	3	-	-
Stabilizers	0.35	0.35	0.3	0.3	0.25	0.2	0.15
Emulsifier	0.15	0.15	0.15	0.14	0.13	0.12	0.1
Total solids	36.5	37.5	38.95	40.94	41.38	40.32	40.75

2.2.1 Milk fat

Fat plays a major role in stabilizing the ice cream structure, as partially coalesced fat is primarily responsible for stabilizing the air bubbles and the foam structure. Keeney (1958) has established that a certain amount of fat destabilization is necessary to obtain good textural properties. Commonly, the source of fat used in the ice cream industry are butterfat, cream and vegetable fat. Fresh sweet cream from fresh sweet milk is used to be one of the best source of butterfat in the ice cream for high quality flavour and convenience. Besides, milk fat also helps in lubricating the freezer barrel during manufacturing and produced a characteristic smooth texture.

Fats are largely composed of a class of molecules called triglycerides, with very small amounts of other molecules, such as phospholipids and diglycerides (less than 2%). The triglycerides consist of a molecule of glycerol, combined with three molecules of fatty acid, as shown in figure.

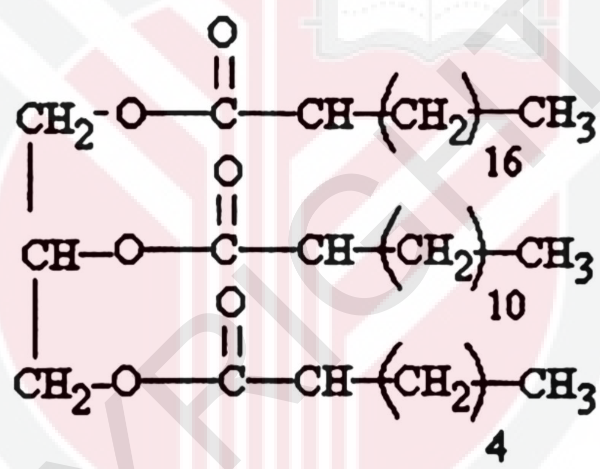

Figure 2.1: Triglycerides

Milk fat triglycerides come in the form of globules. In the serum (water) phase of milk, the globules are surrounded by a protein and phospholipid membrane that stabilizes globules. Native globules range in size between less than 1 μm and more than 10 μm. The unequal size distribution allows the larger globules to float in a process called creaming, which results in a "cream line" at the top of the container. Milk is homogenized to reduce the size of the large globules to less than 1 μm, create a uniform distribution of globules throughout the serum phase, and minimize creaming (Anonymous (a), 2019).

2.2.2 Milk-solid-non-fat (MSNF)

The serum solid or milk-solid-non-fat (MSNF) contain the lactose, caseins, whey proteins, and minerals (ash content) of the product from which they were derived. They play an essential ingredient in ice cream to improve ice cream texture due to protein functionality and help to resist the finished product to the body and chew. In addition, MSNF can allow a higher overrun without the characteristic snowy or flaky textures associated with high overrun, also due to the protein functionality. The best sources of serum solids for high quality products are concentrated skimmed milk and spray process low heat skim milk powder (Goff & Hartel, 2013).

The drawbacks to their use include off-flavours from some of the products and an excess of lactose that can contribute to the sandiness defect that occurs when the lactose crystallizes out of the solution. Excessive lactose concentrations in the serum phase can also reduce the freezing point of the finished product to an unacceptable level.

2.2.3 Sweeteners

Sweeteners or sweetening agents are added to ice cream mix at a rate of usually 12 - 16% by weight. Sweeteners improve the ice cream's texture and palatability, help boost flavours and are generally the cheapest source of total solids. Sweeteners also affect the viscosity of the matrix in which the fat droplets and air bubbles are suspended (Compound, 2015). Sucrose is the best - known sweetener used because it grants excellent flavour. Replacing all or a portion of the sucrose content with corn syrup derived sweeteners has become common in the industry. This sweetener is stated to contribute to the ice cream by a firmer and more chewy body, is an economical source of solids, and enhances the finished product's shelf life.

Sweeteners also called 'nutritive' or 'caloric' sweeteners because they contribute metabolisable energy to the diet. The example of sweeteners used in ice cream include cane and beet sucrose ('sugar'), invert sugar, Corn Starch Hydrolysate Syrup (CSS), high maltose syrup, fructose or high fructose syrup, maltodextrin, dextrose, maple syrup or maple sugar, honey, brown sugar, and lactose. The most common choice of nutritive sweetener is a combination of sucrose (10-12%) and CSS (3-5%) (Goff & Hartel, 2013).

2.2.4 Stabilizer

Stabilizers are water-soluble molecules that are commonly derived from plants, and play a number of roles. A traditionally well-known stabilizer for ice cream, also readily available for home production is Gelatin (derived from animal products). Today, most commercial stabilizers often tend to be various vegetable gums. Some well-known stabilizers are Agar-agar (derived from seaweed), Guar gum (from the Guar bush), Locust Bean gum, Xanthan gum (a by-product of fermented corn starch and a bacteria found in cabbage), Gellan gum (from fermented bacteria), and Carrageenan (from moss and other red algea) (Anonymous (b), 2019). There also exist different ready-made stabilizer mixtures composed of one or more of the mentioned stabilizers.

Generally, stabilizers are used in ice cream to help lower the melting rate of ice cream, and give it a smoother and creamer texture. Other than that, stabilizer will retards or reduce ice and lactose crystal growth during storage as ice crystal is critical factor in the development of smooth and creamy ice cream. According to Adapa et al (2000), guar gum and locust bean gum is widely used as a stabilizer to inhibit ice crystal growth and recrystallization. Besides, the stabilizer is used to prevent wheying-off which refers to the leakage of a clear watery serum layer, which has an undesirable appearance, during the melting of ice cream. Lastly, stabilizers help prevent shrinkage which is defined as the loss of volume in ice cream before any part of the product has been removed from the container (Dubey & White,1997).

2.2.5 Emulsifier

Emulsifiers, which are molecules with ambiphilic properties (part of structure is hydrophilic while other moieties are lipophilic), adopt a favourable position with respect to energy, reducing the surface tension between phases. Emulsifiers are added during the production of ice cream to smooth the texture and thorough distribution of the air cells. Mono and di-glycerides are most common emulsifiers used in ice cream plants. Emulsifiers are not be used more than 0.2% on weight basis. Polysorbate and sorbitan tristearate up to 0.1% are now allowed in dairy products as safe (Abbas Syed, 2018)

The function of emulsifier are to give a stiffness to body and smoothness of texture, give reduction in time of whipping and even whip ability properties. There are also limitations of using emulsifier which are lower melting and textural and body defects.

2.3 Ice cream manufacturing

Ice cream manufacturing is a process to produce ice cream from mixing, pasteurization, homogenization, ageing, freezing and hardening. All of this process is important to produces a good texture of ice cream.

2.3.1 Mixing

First, the ingredients are selected based on the desired formulation and the calculation of the recipe from the formulation and the selected ingredients, then the ingredients are weighed and mixed together to produce what is known as the 'ice cream mix.'

In small capacity manufacturing plants, the dry ingredients are weighed and added to the mixing tanks manually while in large-scale ice cream manufacturing plants usually have multiple mix tanks whose volumes correspond to the plant's hourly capacity (determined by the capacity of the pasteurizer) to ensure that the process is continuous by using automatic batching systems (Kevine, 2017). Generally, these mixing tanks are designed to be indirectly heated, such as double jacketed vats, and they have very efficient agitators to facilitate uniform heat distribution.

Blending requires rapid agitation to incorporate powders, and often high speed blenders are used (Goff & Hartel, 2013). It is important to ensure that the dried ingredients in the mixing tank are properly suspended to avoid lumpiness of the mix. Proper suspension is achieved by thoroughly mixing dry ingredients with part of the sugar before slowly adding the remaining sugar and sifting these dry ingredients into the liquid while slowly agitating the whole mix.

2.3.2 Pasteurization

Next process is pasteurization. Pasteurization is required during ice cream production as a biological control point in the system. In addition to this very important function, pasteurization is absolutely necessary for all ice cream mixtures because of two very important reasons which are to increase the safety of dairy products by destroying diseases that cause microorganisms (pathogens) that may exist in milk or cream, and to increase keeping the quality of dairy products by destroying spoilage microorganisms and enzymes that contribute to the reduced quality and shelf life (Darryl, 2014). Generally, there are two method for pasteurization which are batch pasteurization and continuous (HTST) pasteurization. Batch pasteurizers lead to more denaturation of the whey protein, which some people feel it is giving the ice cream a better body.

In a batch pasteurization system, the proper quantities of ingredients are blended in large jacket vats fitted with some heating devices, usually steam or hot water. The product is then heated in the vat to at least 69°C (155°F) and held for 30 minutes to satisfy legal requirements for pasteurization, necessary for the destruction of pathogenic bacteria. Varied combinations of time temperatures can be used. The heat treatment must be severe enough to ensure destruction of pathogens and to reduce the bacterial count to a maximum of 100,000 per gram (Goff, 2013).

2.3.3 Homogenization

The ice cream mix then undergo homogenization process. Homogenization usually takes place at the pasteurizing temperature. The high temperature produces more efficient breaking up of the fat globules at any given pressure and also reduces fat clumping and the tendency to thick, heavy bodied mixes. No one pressure can be recommended that will give satisfactory results under all conditions (Goff, 2013). Based on Abbas Syed (2018), increase in homogenization pressure caused the reduction in size of fat globules while less pressure during homogenization resulted in increased size of fat particles which were more vulnerable towards shear forces. Homogenization's main purpose is to reduce the size of fat globules, to raise surface area, and to form membrane.

For ice cream mixing, two-stage homogenization is usually preferred, so that clumping or clustering of the fat is reduced thereby can produce a thinner and quickly whipped mix. The melt-down time also can be improved. If a two stage homogenizer is used, a pressure of 2000 - 2500 psi on the first stage and 500 - 1000 psi on the second stage should be satisfactory under most conditions.

2.3.4 Ageing

After homogenization process, the mix is then aged for at least four hours and usually overnight. This allows time for the fat to cool down and crystallise, and for full hydration of the proteins and polysaccharides. Ageing is usually performed in insulated or refrigerated storage tanks such as silos. Mix temperature should be kept as low as possible at or below 5°C, without freezing. An ageing time of overnight is likely to give best results under average plant conditions (Goff, 2013). It is essential that ageing is long enough for crystallization to occur and for emulsifiers to displace some of the protein since both of these processes are important precursors to the next stage in ice cream production (Clarke, 2004). Displacing some of the protein by emulsifiers produces a weaker membrane that can stabilize the emulsion in the ageing tank under the static conditions, but makes it unstable under shear.

While ageing, the chemical ingredients of the base, mainly the proteins, the emulsifiers and the fat molecules, along with any flavours already put into the base "settle", which will greatly improve the texture, smoothness, and stability of the final ice cream. Scientifically speaking, the ageing allows the myriads of individual fat droplets to partially solidify and have their surface coated by the proteins.

2.3.5 Freezing

Next process after aged, is freezing. Generally, air is added during freezing as ice crystals are formed to create ice cream with a smooth texture (Drewett & Hartel, 2007). Ice cream contains a considerable quantity of air, up to half of its volume. This gives the product its characteristic lightness. Without air, ice cream would be similar to a frozen ice cube. The air content is termed its overrun, which can be calculated mathematically. Overrun is usually defined as the volume of ice cream obtained in excess of the volume of the mix. It is usually expressed as percentage of overrun. Too much air will result in a fluffy, snowy unpalatable ice cream while too little air will result in a soggy and heavy ice cream (Kevine, 2017).

Ice cream mix can be frozen in batch or continuous freezers and the conditions used depend on the type of freezer. Batch freezers consist of a rotating barrel that is usually filled one-third to one-half full with ice cream mix. As the barrel turns, the air in the barrel is incorporated into the ice cream mix. Ice cream freezers designed for home use are batch freezers. Continuous freezers consist of a fixed barrel that has a blade inside that constantly scrapes the surface of freezing barrel. The ice cream mix is pumped from a bulk tank to the freezing barrel and the air is incorporated with another pump just before it enters the freezing barrel. The continuous freezing process is much faster than the batch freezing process.

The addition of air is called overrun and contributes to the lightness or denseness of ice cream. Up to 50% of the volume of the finished ice cream (100% overrun) can be air that is incorporated during freezing. The overrun level can be set as desired to adjust the denseness of the finished product. Premium ice creams have less overrun (approximately 80%) and are denser than regular ice cream. At the point of discharge from the freezer (draw temperature), only about 50% of the water in ice cream is frozen. Soft serve ice cream is generated at this point in the freezing process (Anonymous (a), 2019).

2.3.6 Hardening

After the particulates have been added, the ice cream is cooled as quickly as possible in the blast freezer down to a holding temperature of less than -25°C, usually at -30° to -40° C where most of the remainder of the water is frozen. The temperatures and times of cooling will depend on the type of storage freezer. Rapid cooling will promote quick freezing of water and create small ice crystals. Storage at -25°C will help to stabilize the ice crystals and maintain product quality (Anonymous (a), 2019). However, above this temperature, ice crystal growth is possible and the rate of crystal growth is dependent upon the temperature of storage. This limits the shelf life of ice cream.

The rate of heat transfer in a freezing process is affected by the temperature difference, the surface area exposed and the heat transfer coefficient. Therefore, the factors that affect the rate of heat transfer in freezing process is temperature of blast freezer. The colder the temperature, the faster the hardening, the smoother the product. The circulation of air inside the freezer also influenced the rate of heat transfer as rapid air circulation lead to high convective heat transfer.

2.4 Left-over ice cream

Left-over is something, commonly food, that remains unused or unconsumed. The left-over ice cream is the amount of unused ice cream left at the end of the ice cream production. Left-over ice cream also can be defined as food waste. According to Abdel-Shafy & Mansour (2018), the (EPA) U.S. Environmental Protection Agency defines the food wastes as un-eaten foods and food preparation wastes from residences and commercial establishments including restaurants, grocery stores, and produce stands, institutional cafeterias and kitchens, as well as industrial sources such as employee lunchrooms.

There is not so much research out there about the application of unutilized ice cream in the production of ice cream. It is because, typically, the issue on left-over ice cream arises in a small-scale ice cream company or in the ice cream shops only that selling or serving on the soft serve ice cream (Figure 2.2) and hard ice cream in the freezer (Figure 2.3). Not only that, the issues on left-over ice cream also occurred among a start-up company of ice cream since they are still doing trial and error, and prediction on customer's pattern.

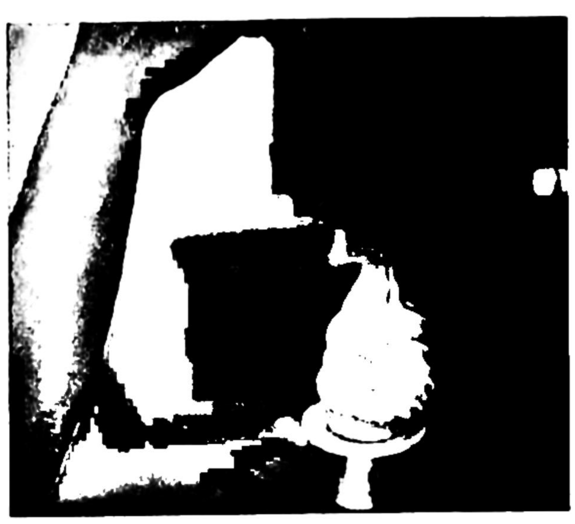

Figure 2.2: Soft serve ice cream

Figure 2.3: Hard ice cream

Cold weather is one of the factor that lead to ice cream leftover. For example, the ice cream shop is often faced with a dwindling number of customers during winter season. When sub-zero temperatures start creeping in, ice cream shops tend to see less and less customers walking through the door (Rmagazine, 2017). People tend to crave for types of hot or warm food instead of ice cream during winter. When the weather is cold, eating or drinking something hot increases the sensation of being warm. (Serena, 2018). Thus, the possibility of ice cream not being consumed by customers in the winter season is high and at the end of the night shift causes the ice cream leftover.

2.4.1 Common practices on left-over food product in food industry

In ice cream production industry, most of the time, there are some ice cream residue will be left at the end of the ice cream production process. The ice cream residue will be removed by cleaning and washing operation. Thus, it creates wastewater. Ice cream or dairy wastewaters are characterized by high biological-oxygen demand (BOD) and chemical oxygen demand (COD) concentrations, and generally contain fats, nutrients, lactose, as well as detergents and sanitizing agents. Dairy effluents decompose rapidly and deplete the dissolved oxygen level of the receiving streams immediately resulting in anaerobic conditions and release of strong foul odours due to nuisance conditions (Shete, 2013). Anaerobic fixed bed reactors (AFBRs) has been successfully and widely applied for the treatment of dairy industry wastewater due to its capacity for microorganism retention on the support and, therefore, the hydraulic retention time can be considerably reduced. According to U. B. Deshannavar et. al. (2012), they have studied the up low anaerobic fixed-bed reactor for digestion of dairy industry effluent using polypropylene pall rings as a packing media and found that average COD removal efficiency of 87% and maximum biogas production of 9.8 l/d was achieved. Therefore, the wastewater treatment commonly gives a lot of advantages to the company as well as the environment.

In various food industry such as bakery, bakery wastes (solid waste) are extensively used as feed for farm animals which reduces their disposal and alleviates environmental issues (Westendorf et al., 1996). Besides, solid waste may be recovered by cooking waste dough to produce breadcrumbs and by passing cooked product onto pig farmers for fodder (K.Wang Lawrence, Yung-TSe, Howard, & Constatine, 2006). This only applied if the bread complies with health and safety regulations. Other than that, leftover bread also re-using in food processing to produce pizza, bread and water meal and cheese pie (Nježić, Živković, & Cvetković, 2010).

Waste product or product leftover from various food processing commonly practices by treating the waste into another beneficial product and gives a lot of benefits to human and environment. However, the application of left-over ice cream into valuable product is limited since the situation occurs in small-scale company or start-up company and ice cream shops only. Most of the big industrial company of ice cream had frequently tracked the production trend and managed to minimize the waste. Therefore, the goals of this study are to convert the unused ice cream from the ice cream production into value added product.

2.4.2 Common practices on left-over ice cream in small-scale ice cream production

There are no particular practices out there to manage the left-over ice cream, as the issues in the manufacture of ice cream in a small company or ice cream shops are minor. Logically, the left-over ice cream will be thrown away instead of being refreeze and reused for the next day. Any waste products in these earlier days were so small in quantity that when they were thrown away the area over which nuisance might extend would be very small (Walker, Dodge, Madden, & Walker, 2014). Moreover, each time the ice cream is removed from the freezer, and the surface begins to thaw, the ice cream loses quality (Anonymous (c), 2007). The quality of ice cream is dropped, as it is easy to melt, low taste and not smooth as before. When frozen ice cream thaws, the ice crystal disappear so that coagulation is able to continue. It leaves a melt with a weak structure which differs from the fat network present in the original mix (Sherman, 1966). Reuse the left-over ice cream for the next day may lead to unpleasant taste on the ice cream which may affect the ice cream business reputation. Therefore, the focus of this research is to convert the left-over ice cream into value-added product. Besides, there are several articles sharing the general practices on the left-over ice cream. In dessert kitchens, there are special ice cream machines for "reworking" yesterday's ice cream, in other words, melting it down, remixing and refreezing the ice cream without it forming ice crystals (Anonymous (d), 2019). A forum on the internet shared about how gelato shops handled left-over ice cream. One of the gelato shops practice is to resell the left-over ice cream the next day but this can be done not more than two days. At the end of the second day, any unsold gelato is given to employees to be taken home or thrown out. (Anonymous (e), 2019).

2.4.3 Application of left-over ice cream

Human are very creative in innovate something. Many articles and websites on the internet show the practical or application of unused ice cream into value-added product. However, these applications usually practical for a small-scale ice cream business and homemade only. For example, the left-over ice cream can be converted into good baked such as ice cream chocolate chip cookies, chocolate ice cream muffins, vanilla ice cream bread and melted ice cream cake (Jen, 2019). Besides, the left-over ice cream also can be modified into bread. Table 2.2 shows the example of bread making from left-over ice cream (Chef, 2019).

Table 2.2: Bread making from ice cream leftover

Ingredient	¾ cups of self-rising flour, 1 cup of ice cream leftover.
Instruction	1- Measure the amount of the liquid 2- Add ¾ cups of self-rising flour for every 1 cup of melted ice cream 3- Mix both ingredients together 4- Place in a buttered loaf pan and bake for 40-45 minutes at 350 degrees.

The most highlighted baked product out there is cake produced from melted ice cream. Table 2.3 shows the example of melted ice cream cake recipe (Brandie, 2019). The nutritional fact also provided in Figure 2.4.

Table 2.3: Cake produced from melted ice cream recipe

Ingredient	**For the cake:** 1 box white cake mix 2 cups melted ice cream measure while melted 3 eggs **For the icing:** 1 cup confectioner's sugar 2 tablespoon milk sprinkles
Instruction	1. Preheat oven to 350°F degrees. 2. Spray bundt pan with non-stick cooking spray. 3. Combine cake mix with eggs and melted ice cream. 4. Stir until combined well. 5. Pour batter into greased bundt pan. 6. Bake for about 33-36 minutes. 7. Until it springs back to the touch and a toothpick comes out clean. 8. Allow cake to cool completely then turn cake out onto a serving plate. 9. For the icing, whisk together confectioner's sugar with the milk. 10. Adding enough milk until it has reached the desired consistency. 11. Then drizzle the icing all over cake. Finally, drop a few sprinkles on top for fun.

Nutrition

Calories: 230kcal | Carbohydrates: 45g | Protein: 3g | Fat: 4g | Saturated Fat: 2g | Cholesterol: 47mg | Sodium: 275mg | Potassium: 81mg | Sugar: 24g | Vitamin A: 130IU | Vitamin C: 1.7mg | Calcium: 113mg | Iron: 0.9mg

Figure 2.4: Nutritional fact of cake produced from melted ice cream

2.5 Conventional butter cake

A butter cake is a cake in which one of the main ingredients is butter. Butter cake is baked with basic ingredients such as butter, sugar, eggs, flour, and leavening agents such as baking powder or baking soda. It is considered as one of the quintessential cakes in American baking. The most common forms are white and yellow cake. It is flavourful, soft and light in texture, moist enough to stand on its own or to accommodate a variety of frostings and toppings (Beranbaum, R.L. 2016). It is found that the ice cream consist of ingredient that are similar to the ones in the butter cake such as sugar, fat or butter and vanilla essence. Thus, butter cake is the most suitable bakery product that can be used as a control sample in this research.

2.5.1 Standard composition of butter cake recipe

Traditional formula relies on the creaming method to incorporate air into the batter to produce the cake's characteristic dense and moist texture. Current butter cakes make use of chemical leavening in the form of baking soda or baking powder, or a combination of both to reduce mixing times and achieve similar results. While the traditional formula may have consisted of equal quantities of flour, fat, sugar and eggs, today's formulas involve multiple variations. Table 2.4 shows a standard butter cake recipe (Taip, Mazlina, Kamal, & Aziz, 2014)

Table 2.4: Standard butter cake recipe

Ingredient	Weight composition (%)
Flour	38.12
Castor sugar	35.25
Butter	26.63
Fresh milk	23.50
Eggs	25.59
Baking powder	0.78
Vanilla essence	2.35

2.5.2 Butter cake production

Creaming method is usually used for butter cake production (Gisslen, 2009). The production of butter cake in this research is using the experimental equipment and method.

First, measure all the ingredients using a weighing at controlled room temperature of 20°C to 25°C. Mix the butter and sugar by using an electric mixer until fluffy and light at moderate speed for 8 to 10 minutes. Mixing is the method to beat the sugar and butter together to form a homogeneous batter. Air bubbles will trap in the mixture during the process. The tiny air bubbles expand during baking to form the light, airy, fluffy and soft texture of the cake (Kp, 2016). Then, add egg gradually and mixing is continued for another five minutes. Add all the dry ingredients such as superfine flour and baking powder into the mixer. Next, add the vanilla essence as the last ingredient. Continue mix the ingredient on the slowest speed to minimize gluten formation. Stop immediately once the batter is homogenous and free from lumps. Overmixed cake is tougher and may form noticeable pits and holes (think of bread). The cake can crack, and develop long tunnels in extreme cases. (Shailynn, 2020). Lastly, pour the batter into a tray and baked at 180°C for 35 minutes (Gisslen, 2009). The temperatures and times for baking butter cake can vary from oven to oven. This variation is due to the size and position of the elements of the oven, which affect the time and temperature required.

CHAPTER 3 : METHODOLOGY

In this chapter, the method of the experiment was explained. The step consists of two stages which are production of ice cream and production of cakes from melted left-over ice cream. The (melted) ice cream produced in the first stage was used as a control sample for making formulated cakes due to time constraints and limited availability of left-over ice cream from ice cream premises. The viscosity analysis was conducted between ice cream mix (after 'ageing' process) and melted left-over ice cream during the first stage of preparation of ice cream. Physical, textural and sensorial analysis of cakes were determined during preparation of cakes in the second stages. Data obtained from analysis was recorded and discuss in next chapter.

3.1 Production of ice cream

The production of ice cream samples were conducted in the Food processing Quality Lab, Faculty of Engineering, Universiti Putra Malaysia (UPM). Ice cream mixture was prepared based on the given formulation. The detailed of the ingredients will be show on table below.

3.1.1 Preparation of ice cream mix formulation

The ice cream type used for this control sample is a soft ice cream. The ice cream formulation was prepared and adjusted based on the formulation reported by (Rahman et al., 2019). Hence, the sample was prepared as shown on the Table 3.1 below:

Table 3.1: Formulation was used to prepare soft ice cream

Ingredients	**Weight Composition (%)**	**Mass for each batch of 800g (g)**
Water	60.9	487.2
Skimmed Milk Powder	14.5	116.0
Sugar	16.3	130.4
Whey powder	3.6	28.8
Creamer	3.6	28.8
Emulsifier	0.4	3.2
Stabilizer	0.3	2.4
Flavouring	0.4	3.2

The process of ice cream then continue with ice cream production which including weighed the ingredients, mixed, pasteurized, homogenized, ageing, and froze.

3.1.2 Weighed ingredient

Dry ingredient such as sugar, skimmed milk powder, whey powder, creamer, emulsifier, stabilizer and flavouring were weighed using a weighing balance before put them together in the mixing bowl. The weight of each ingredients was referred to the mass that have been calculated.

Figure 3.1: The ingredients were weighed using a weighing balance

3.1.3 Mixed

All the ingredients were mixed and blend by using a mixer (Model 5K5SS, KitchenAid, St Michigan, USA) at room temperature for five minutes until apparent homogenous mixture were obtained.

Figure 3.2: Mixing process

3.1.4 Pasteurized

The liquid mixture was then batch pasteurized on the stove until the temperature of the mixture reached of 80°C and was held for 15 seconds. Digital thermometer was used to detect the temperature of the mixture.

Figure 3.3: Pasteurization process on the stove

3.1.5 Homogenized

The mixture was immediately transfer into a jug after the process of pasteurized had been completed. The mixture was then undergo two-stage homogenization process using a lab scale homogenizer (Success Technic Industries, Model WT500, Malaysia). The homogenization process for first stage was running at 12 000 rpm for 120 seconds and then reduced to 10 000 rpm for another 120 seconds at second stage.

Figure 3.4: Lab scale Homogenizer

3.1.6 Ageing process

After homogenized, the liquid ice cream mix was transferred into a container and rapidly cooled at constant temperature of 4°C overnight for ageing. This process is vital in the ice cream production to improve the whipping qualities of mixture and texture of the ice cream. After ageing process had been done, 5 ml of ice cream mix was taken out for viscosity analysis.

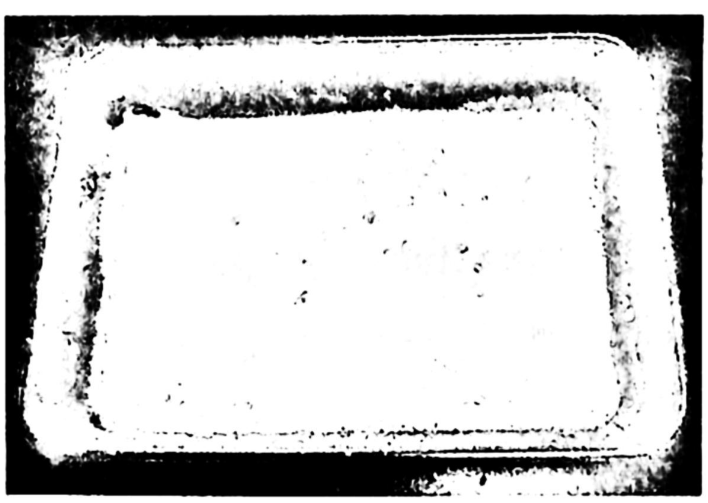

Figure 3.5: Ice cream mix after homogenization process

3.1.7 Freezing process

The aged ice cream mix was then whipped and froze in a home-style batch ice cream machine (Breville, Model BC1600, Australia) which has the maximum capacity of 1 litre. The ice cream mix was undergo cooled and froze in the machine at temperature about -20°C.

Figure 3.6: Ice cream mix after undergo freezing process

3.2 Melted ice cream

To mimic the situation that happens in ice cream store or shop, the frozen ice cream was taken out from the batch ice cream machine right after the freezing process had been completed. The frozen ice cream then allowed to melt in the chiller which was about 4°C for 12 hours. The ice cream was expected to melt completely during this period for total loss of the ice cream structure. Since the ice cream shops typically closed at 10PM and opened at 10AM for the next day, thus, this period was chosen as the control period to keep the left-over ice cream until it is reused on the next day.

After 12 hours of melting process had been finished, 5 ml of melted left-over ice cream was taken out for viscosity analysis and the rest would be used for production of formulated cakes.

Figure 3.7: Melted left-over ice cream

3.3 Production of cakes from melted left-over ice cream

The melted left-over ice cream from the production of ice cream in the first stage was used as a main ingredient in the production of formulated cakes. The preparation and production of cakes from melted left-over ice cream were conducted as followed below.

3.3.1 Formulation of cake samples

The recipe used for making cakes from melted left-over ice cream was adapted from Brandie (2019). Three main ingredients were used in the production of formulated cakes which are instant sponge cake mix (Dr. Oatker by Nona, Malaysia), melted left-over ice cream and eggs. Instant cake mix was used to get the simplest cake made from melted left-over ice cream that is convenient for anyone to do. Four suggested formulation for making cakes from melted left-over ice cream were carry out during the lab session. The formulations were listed in the Table 3.2. In this study, cakes made from instant cake mix without adding melted left-over ice cream were used as a control sample. The control sample required 5 eggs, 100g butter and 100ml of water as written on the package's box. The amount of eggs used for formulated cakes were varied from 0-3 eggs. From the preliminary work conducted beforehand, inserting 4 eggs into the formulation would cause the cake batter to runny and the cake does not shape well after baking.

Table 3.2: Formulation of cake produced from melted left-over ice cream

Formulation	Ingredients
A	1 box of instant cake mix
	2 cups of melted ice cream
	3 eggs
B	1 box of instant cake mix
	2 cups of melted ice cream
	2 eggs
C	1 box of instant cake mix
	2 cups of melted ice cream
	1 eggs
D	1 box of instant cake mix
	2 cups of melted ice cream
	0 eggs

1 box of instant cake mix is equivalent to 400 g while 2 cups of melted ice cream is equal to 445 g.

3.3.2 Weighed ingredient

For each cakes produced from melted left-over ice cream, the melted ice cream were weighed using a weighing balance according to the mass that have been calculated.

Figure 3.8: Instant cake mix, melted left-over ice cream and eggs as main ingredient for formulated cakes

Figure 3.9: Melted left-over ice cream was weighed using a weighing balance

3.3.3 Mixed

Instant cake mix and melted ice cream were then poured into a mixing bowl and mixed for 4 to 5 minutes to ensure all the ingredient inside homogenized. Eggs was gradually added and mixing was continued for another one minutes on the slowest speed to minimize gluten formation.

Figure 3.10: Mixing process

3.3.4 Baked

After all the ingredients were mixed, the batter was poured into a square tray with a dimension of 6.5cm (height) × 21cm (width) × 21cm (length) and baked at 180°C for 45 minutes as per the instruction on the packaging. The baked cake then allowed to cool for 30 minutes in the oven before it was taken out to avoid soggy edges (Good, 2020).

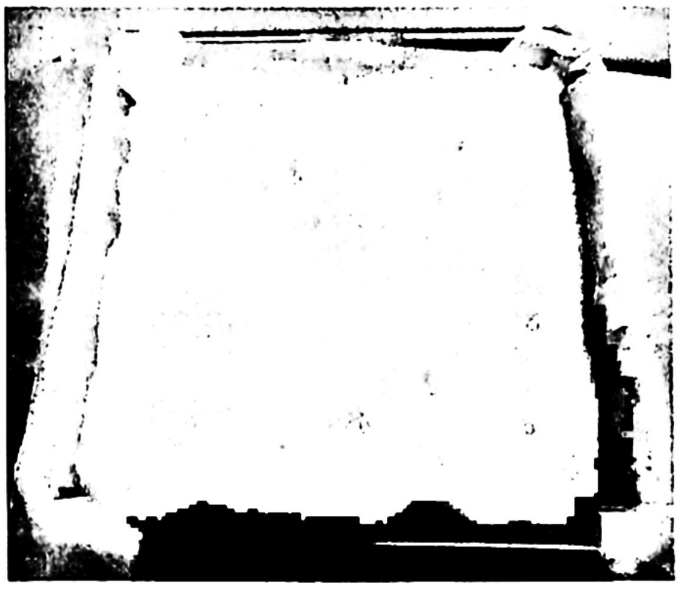

Figure 3.11: Batter was poured into a square tray before baking process

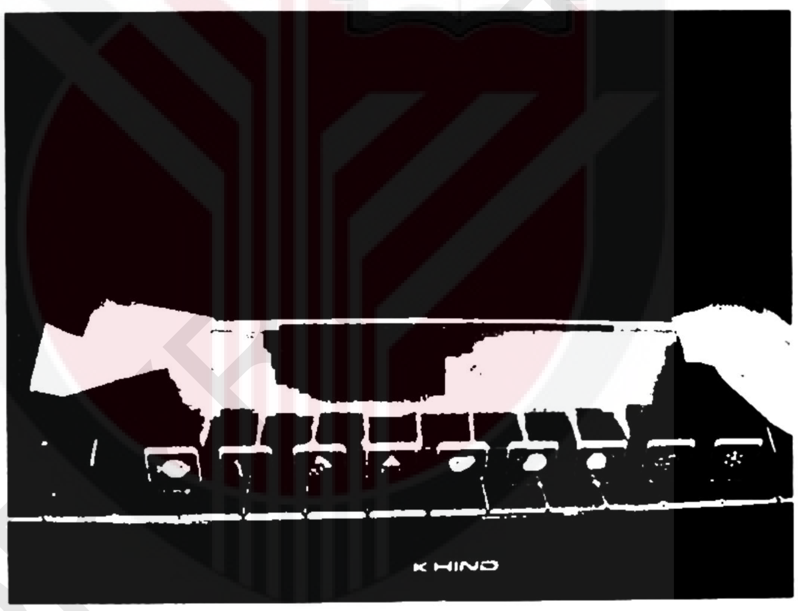

Figure 3.12: Cake was baked in the microwave

3.4 Viscosity analysis of ice cream mixture

The viscosity analysis were conducted to analyze two types of mixture which are ice cream mix (after 'ageing' process) and melted left-over ice cream.

The rheological measurement for the ice cream mix and melted left-over ice cream were performed on a dynamic rheometer (AR-G2, TA instrument, New Castle, USA) using cone plate configuration of with 1° and 60 mm diameter. The sample was loaded on rheometer base plate and was allowed to rest for 10 min to prevent the influence of structural modification during sample handling and loading. The shear rate for this sample was set from 0 too $300s^{-1}$.

Figure 3.13: Rheometer (AR-G2, TA instrument, New Castle, USA)

3.5 Physical, textural and sensorial analysis of cakes

The analysis of cake properties was performed on the sample of cake produced from melted left-over ice cream including conventional cake sample. The analysis that was conducted is physical characterization, textural properties, and sensory evaluation. The physical analysis of cakes consist of moisture, volume index, contour and symmetry index, and cake density and specific volume.

3.5.1 Moisture analysis

Approximately 2 g of the cakes sample was weighed to the nearest 0.001 g in a tared weighing balance. The dried cakes were analyzed for moisture by using a moisture analyzer (AND MX-50, A&D Weighing, Japan).

Figure 3.14: Moisture analyzer (AND MX-50, A&D Weighing, Japan)

3.5.2 Volume index

Volume index of cakes were measured according to the method explained by Rahmati and Tehrani (2014). Cakes were cut vertically through their centre and the heights of the samples were measured at three points (B, C, D) along the cross-sectioned cakes using the template as shown in Figure 3.15. C is the height of the cake at the centre and B and D are the heights of the cake sample at points 2.5 cm away from the centre towards the left and right sides of the cake, respectively.

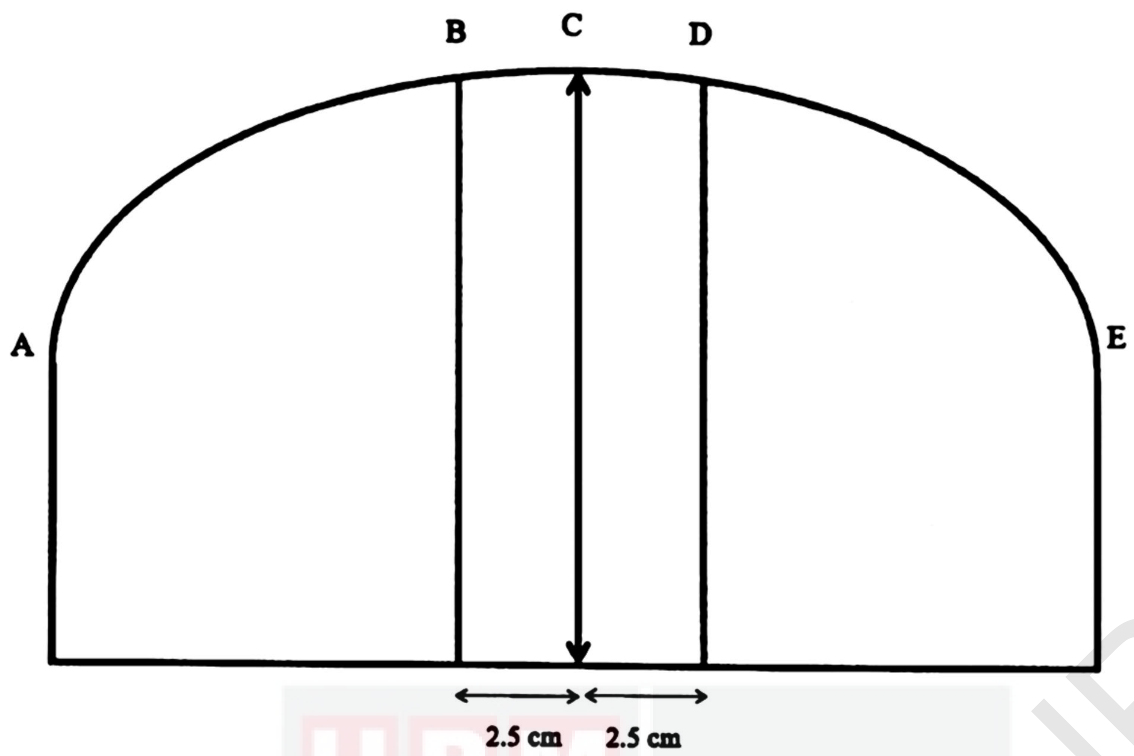

Figure 3.15: The position of points on cake to enable calculation of cake morphology

Volume index was calculated by the following equation:

Volume index = B + C + D (1)

3.5.3 Contour and symmetry index

Contour and symmetry indices were calculated using the following equations:

Contour = 2C−B−D (2)

Symmetry = B−D (3)

A positive symmetry index shows that the cake rises more in the central area, while a negative symmetry index indicates that the central area of the cake has fallen during the final part of baking or during cooling.

3.5.4 Cake density and specific volume

The pan used for the cake sample was square in geometry with the dimension of 6.5cm (height) x 21cm (length) x 21cm (width). The volume of cake was calculated based on the dimension of the pan except for the height. The equation used was as follows:

Cake volume = height of cake (h_{cake}) x length of pan x width of pan (4)

The cake height was calculated by taking the average 5-point height (ABCDE) of the cake as shown in Figure 3.15 previously:

Cake height = $[h_{cakeA} + h_{cakeB} + h_{cakeC} + h_{cakeD} + h_{cakeE}] / 5$ (5)

Cake density was measured by dividing mass of the cake by its volume.

Cake density, ρ (g/cm^3) = m_{cake} / V_{cake} (6)

where, m represents mass (g), V represents volume (cm^3), and ρ represents density (g/cm^3).

Specific volume is the amount of air that remains in the final product. High gas retention and high gas expansion of product lead to high specific volume. Cake specific volume was calculated by dividing the volume of the cake by its mass:

Specific volume = V_{cake} / m_{cake} (7)

3.5.5 Textural properties analysis

Texture profile analysis (TPA) was performed to evaluate the texture of the cakes using Texture analyzer (TA.XT Plus, Stable Micro System, England). The cake samples were cut into 25 mm × 25 mm × 25 mm cubes from the midsection of the cakes before TPA measurement. A standard double-cycle program was used to compress the cake samples at a speed of 1.0 mm/s with 50% strain of its original cube height (Taip, Mazlina, Kamal, & Aziz, 2014) using a 36 mm diameters cylindrical probe without the waiting time before starting the second compression. Firmness, cohesiveness, springiness and chewiness were calculated from the TPA graph. The measurements were carried out in triplicate for each formulated cakes.

Figure 3.16: TA-XT2 texture analyzer (Stable Microsystems, Surrey, UK)

3.5.6 Sensory evaluation

The hedonic test was conducted with 20 volunteers from various socioeconomic backgrounds (staff and students from Faculty of Engineering, UPM Serdang, Malaysia). All cake samples made from melted left-over ice cream including the control sample were evaluated. The samples were labelled as A, B, C, D and E (control). Cakes were evaluated on the basis of acceptance of their colour, odour, softness, sweetness, taste and overall acceptability on a 5-point hedonic scale. The scale of values ranged from "dislike extremely" (score 1) to "like extremely" (score 5). Enough space was given to handle the samples and questionnaire, and evaluation time was not constrained.

3.6 Summary of methodology

Chapter 3 were discussed on the methodology used in this study to produce ice cream and cake from melted left-over ice cream. After that, the test that required for analysis such as viscosity of ice cream mixture and melted left-over ice cream, textural properties, physical characteristics and sensory evaluation for all cakes were explained.

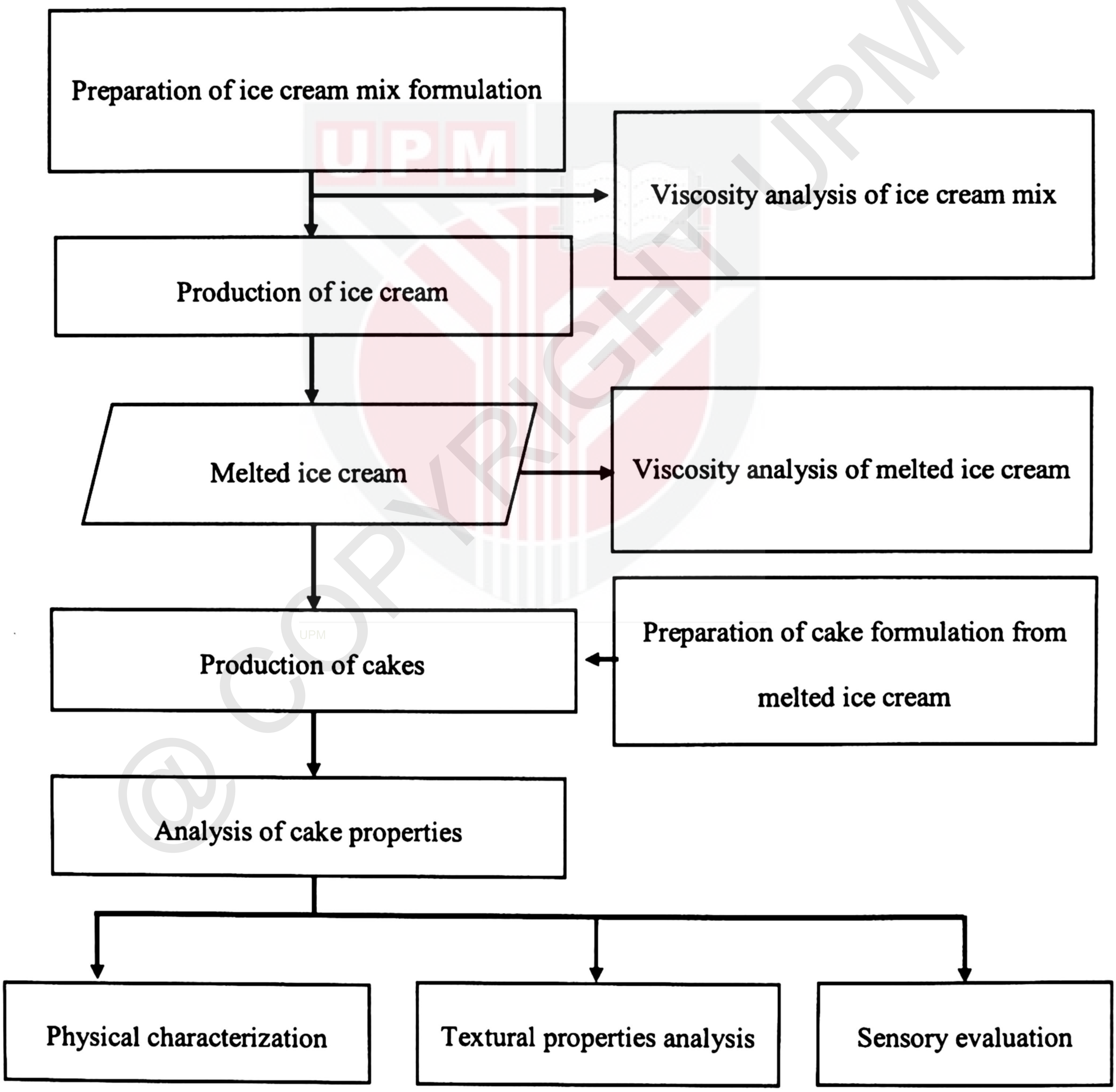

Figure 3.17: Flow diagram of production cake from melted left-over ice cream

CHAPTER 4 : RESULT AND DISCUSSION

This chapter consists of the results of viscosity of ice cream by comparing the value of viscosity of ice cream mix (after 'ageing' process) and melted left-over ice cream. Besides, there is also the result of physical characterization and textural analysis of cakes produced from melted left-over ice cream including conventional control sample that was obtained from the experiment which are moisture, volume index, contour and symmetry index, cake density and specific volume and textural profile analysis (TPA). The sensory evaluation also conducted to evaluate the cake's liking and preferences.

4.1 Viscosity Analysis

The viscosity of ice cream mix had been carried out based on research methodology. The bar graph for viscosity of ice cream mix (after 'ageing' process) and melted left-over ice cream had been plotted as shown in Figure 4.1.

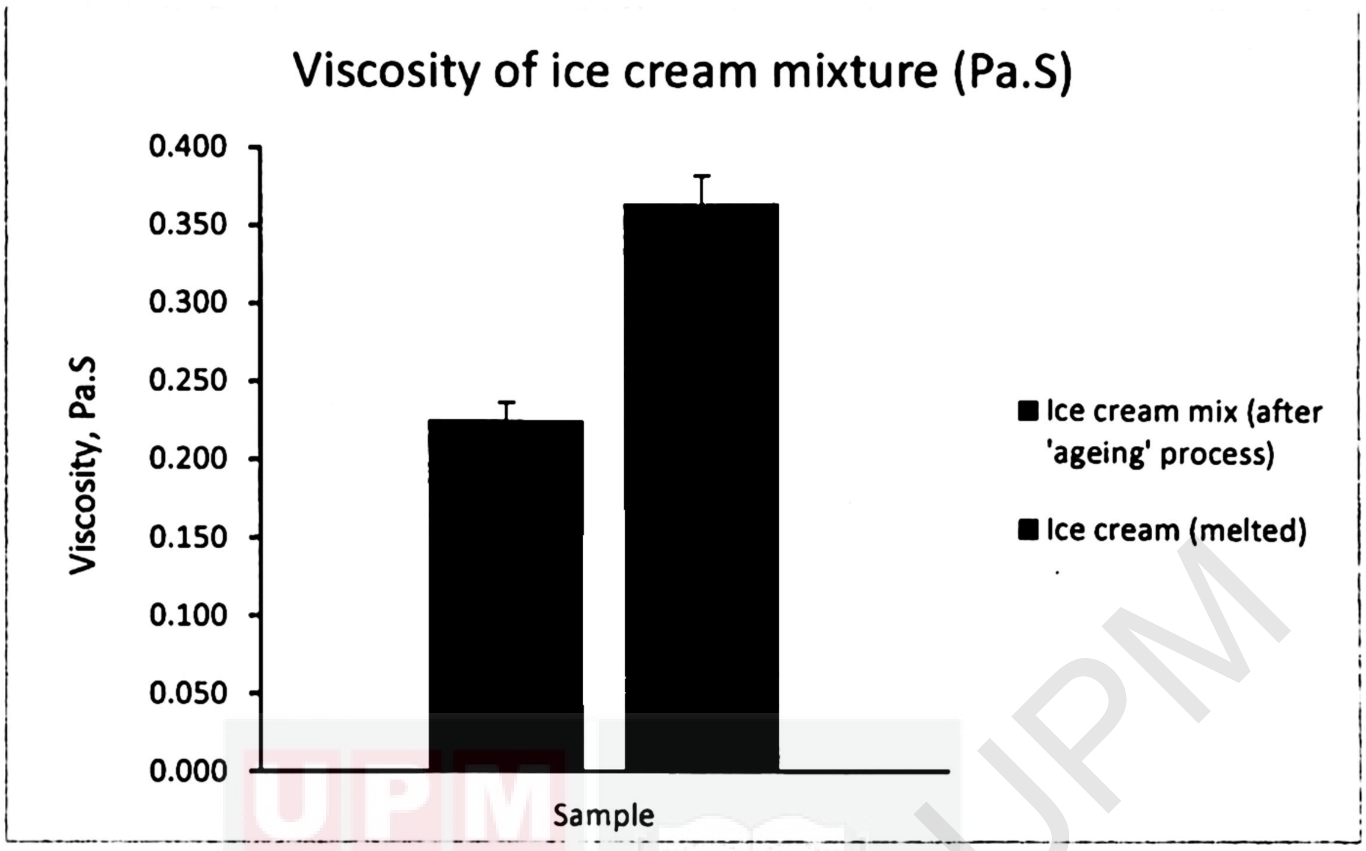

Figure 4. 1: Viscosity of ice cream mix

Figure 4-1 shown the value of the viscosity of ice cream mix. Based on figure 4.1, the viscosity of ice cream mix (after 'ageing' process) and melted left-over ice cream was 0.225 Pa.s and 0.364 Pa.s respectively. The result obtained shown that the viscosity of melted left-over ice cream is higher than the viscosity of the ice cream mix (after 'ageing' process). Goff and Hartel (2003) stated that for the viscosity of ice cream mix after ageing process, there were no ideal mix value but it was typically in the range of 0.1 Pa.s to 0.8 Pa.s. Thus, the value of viscosity obtained for ice cream mix (after 'ageing' process) in this experiment was acceptable.

In this experiment, both ice cream mixes were generally subjected to the same process of ice cream production which are from mixing, pasteurizing, and homogenizing to aging. One of them, however, had been freezing and melting in order to distinguish and compare the viscosity value. Freezing process is one of the significant processes that influence the ice cream's viscosity. Generally, in the beginning of the freezing process there is an unfrozen phase in which, as the temperature drops, the concentration of the solution (unfrozen phase) increases with less and less water occurring (Goff, H. D., E. Verespej, and A. K. Smith., 1999). In fact, during this process, ice crystallization and fat crystallization also developed. This indicates that the ice cream mixture is more viscous during the freezing process.

When the ice cream is melted, the stability of the mix would be 'disturbed' by heat shock and temperature changes. The elements inside the ice cream start moving apart. Component that was most affected was ice crystal. As the ice cream was exposed to high temperatures, the ice crystal started to melt and transform into water. However, even the ice crystal melts, the ice cream does not 'melt' drastically since there is an emulsifier which provided increased stability to heat shock. Furthermore, the ice cream was only exposed to chiller temperature (4°C) in this experiment. The ice crystal also keeps trapped within the network of fat globules because there is an emulsifier concentration that controls the extension of fat destabilization or partial coalescence. This largely support those by (Baer, Wolkow, & Kasperson, 1997). In their research, they found that those ice cream that were added with emulsifier exhibited the highest stability to heat shock, compared which the ice cream which contained no emulsifier. That is why it is important to add emulsifier in the ice cream manufacturing process. Additionally, most of the element or molecule inside the melted ice cream was become larger than the ice cream before melted. Food (2014) found that larger molecules had tend to have higher viscosity while larger molecules had higher intermolecular forces attracting each other and with the greater strength that generates molecular flow. Thus, results for this experiment for viscosity was acceptable.

4.2 Cake Properties Analysis

The analysis of cake properties was conducted on the sample of cake produced from melted left-over ice cream including conventional control sample as stated on the research methodology. The analysis that was performed is physical characterization, textural profile analysis and sensory evaluation. Table 4.1 shown the result obtained.

Table 4. 1: Physical characterization of cake produced from melted ice cream and control sponge cake and textural profile analysis.

Physical characteristics	Types of formulation				
	Control	A	B	C	D
Moisture (%)	35.32 ± 0.47	39.09 ± 0.31	33.18 ± 0.52	34.20 ± 0.30	32.54 ± 0.75
Volume index (cm)	22.53 ± 0.91	17.92 ± 0.60	16.42 ± 0.10	16.78 ± 0.70	13.77 ± 0.58
Contour (cm)	0.77 ± 0.06	0.38 ± 0.19	0.88 ± 0.38	0.62 ± 0.11	-0.47 ± 0.15
Symmetry index (cm)	0.17 ± 0.06	0.15 ± 0.05	0.12 ± 0.03	0.08 ± 0.03	-0.13 ± 0.06
Density (g/cm^3)	0.34 ± 0.02	0.48 ± 0.01	0.47 ± 0.01	0.43 ± 0.03	0.45 ± 0.02
Specific volume (cm^3/g)	4.07 ± 0.22	2.84 ± 0.08	2.90 ± 0.05	3.16 ± 0.22	3.02 ± 0.14
TPA: Firmness (N)	3.48 ± 1.14	3.66 ± 0.44	4.11 ± 0.16	4.13 ± 0.83	3.35 ± 0.54
Springiness (mm)	0.92 ± 0.02	0.90 ± 0.03	0.94 ± 0.03	0.92 ± 0.01	0.71 ± 0.08
Chewiness (N.mm)	2.23 ± 0.77	2.03 ± 0.26	2.63 ± 0.14	2.57 ± 0.53	1.49 ± 0.38

Cohesiveness (-)	0.69 ± 0.01	0.61 ± 0.02	0.68 ± 0.01	0.67 ± 0.01	0.62 ± 0.04

A: Cake produced from melted ice cream with 3 eggs, B: Cake produced from melted ice cream with 2 eggs, C: Cake produced from melted ice cream with 1 egg, D: Cake produced from melted ice cream with no eggs

4.2.1 Physical characterization of cakes

Table 4.1 shows the physical characteristics of cake produced from melted left-over ice cream and control sample.

Sample A had the highest moisture content while sample D displayed the lowest moisture content which were 39.09% and 32.54% respectively. Eggs and sugar are known to be a factors that influence the moisture retention capability during mixing and baking. The egg yolk itself contributes protein, some fat, flavour, and emulsifying lecithin. Emulsifiers are one of those agents that hold together water and fat. Thus, by adding more eggs to the batter, it enables the batter to hold extra liquid and consequently extra sugar (Gray, 2017). This create a moister and sweeter cake that will still bake up with a good structure.

According to the result obtained, all the formulations containing melted left-over ice cream possessed high moisture content with about the same amount as in the control sample. This is mainly due to the availability of stabilizer in melted ice cream composition. Stabilizer has the ability to bind and retain water in food.

Sample D displayed the lowest moisture content due to the eggless formulation used in this experiment. Although the amount of sugar in the ice cream was the same for all cake made from melted left-over ice cream, the absence of eggs may have a high effect on the water absorption rate. The presence of sugar in the cake alone without eggs was not strong enough to hold the water and caused high water losses during baking. This result is supported by Lin, Tay, Yang, Yang, & Li, (2017) which stated that the eggless cakes showed lower moisture contents.

Volume index of cake indicates the amount of air entrapped in the cake. Zhou et al (2011) stated that although high volumes do not always indicate a desirable cake, low volumes generally indicate a heavy and less desirable crumb. Generally, the amount of air cells in cake depends on several reasons including mixing conditions, amount of eggs, baking powder and water vaporization during baking that is of high importance. Higher eggs content in the control sample caused the volume index to be higher than all the formulated samples. Sample D has the lowest volume index since there was no egg used in the formulation.

Generally, cakes with higher volume exhibited higher central loaf height. Normally, a high contour value indicates a peaked cake while a flat cake would have a low value of contour. Even though Sample A had the highest volume index among all formulated cake made from melted ice cream, however, it had lower contour index value (among cakes made using eggs) due to its flatter top surface. Sample D had a negative contour value of -0.47cm which indicated that the top surface had sunken in the middle. The symmetry index was inversely proportional to the amount of eggs added. The control sample which contained the highest amount of eggs had the highest symmetry index of 0.17 cm. Sample D which contained no egg had a negative symmetry index of -0.13cm. The negative value of sample D corresponds to the sunken central area of the cake at the end of the cooling process. Figure 4.2 illustrates how the cake behaved after the baking process ended.

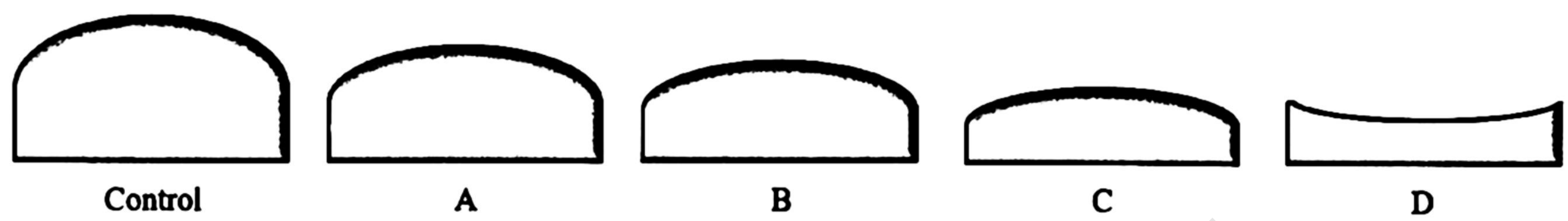

Figure 4.2: The body formation of cakes samples after baking

In cake-making process, the addition of egg is essential as the whipping of egg enters air bubbles that help to build the cake's structure. Excluding eggs from cake formulation would weaken its structure. The air incorporated by whipping the eggs adds volume to those cakes, making them springy and elastic. It is also necessary to consider the period of whipping eggs to prevent the batter from reaching their limits. Once the limit is reached, the matrix of protein will begin to break down and the foam will collapse (Moncel, 2019). The egg whites will become grainy, watery, and flat. Proper egg whipping technique and time consideration thus affect the batter structure. In addition, egg is also a rich source of emulsifying agent which facilitates the incorporation of air and inhibits wheat starch gelatinization. Without eggs, the batter's structural framework may become dense as less air is incorporated during the mixing process and the ingredient does not fold together.

It can be seen from the data in Table 4.1 that the value of density for all formulated cakes are higher than control sample. It can be conclude that, the addition of melted left-over ice cream increased the density of cake. This may be due to its higher ability to retain water. Melted left-over ice cream also contained emulsifier inside which readily contributed to the increased ability of cakes with melted ice cream to retain water.

The specific volume of control sample showed the highest value of 4.07 cm^3/g as compared to other cakes. Cake produced from melted left-over ice cream displayed significantly lower specific volume than control sample. The addition of melted left-over ice cream and varying amount of eggs used for making cakes caused the cakes denser and led to lower volume expansion.

4.2.2 Cake texture

Texture result are shown in Table 4.1. The texture parameter tested were firmness, springiness, chewiness and cohesiveness of cakes.

Vary amount of eggs influence the firmness of the cakes. According to the result obtained, the decreasing quantity of eggs (except for eggless formulation) lead to increasing firmness due to decrease of porosity. Sample C which contained only one egg shows the highest value of firmness which was 4.13 N. This may probably due to the sugar-egg ratio in the formulation of sample C may not be balanced between them which resulting in excess of sugar content. Adding more sugar until it passes the limit may causing the proteins in the flour and eggs to form weaker bonds, and creating a tenderer. Excess sugar could weaken a cake structure so much that it collapse (Gray, 2017). Thus, the cake became firmer as compared to other samples.

Sample D with no eggs at all showed the least firmness value from the overall cake produced. The lowest value of firmness did not mean that the texture of the cake is soft with elastic but it was rather squishy. This may probably due to lack of emulsifier in the cake. The amount of emulsifier inside the melted left-over ice cream and instant cake was too little, that it could not retain the structure of the cake strong enough. That is why egg plays an essential part in cake formulation. Egg act as emulsifier to combine and bind two substance that normally would not adhere (butter and liquid). Without the presence of eggs, the batter might not have mixed well with other constituents, leading to cake falling in the middle (as explained in the previous section) and the cake becomes squishy.

Springiness is a textural parameter, which related to elasticity of sample. Springiness in TPA is related to the height that food recovers during the time that elapses during the end of first bite and the start of the second bite. If the springiness high, it requires more mastication energy in the mouth (Rahman M.S & Al-Mahrouqi A.I, 2009). There was no significant differences springiness value for each sample which range of 0.90 until 0.94 except for sample D. Thus, it shows that as long as the egg is present in the cake, the varying amount of eggs did not significantly affect the springiness value. In this case, sample D showed the lowest springiness value compared with other samples. This is possibly due to the absence of eggs that causes the cake to decrease in porosity. Low porosity means the cake was not expanding well. In fact, sample D had fallen in the centre after baking and cooling process.

There is a strong correlation between chewiness and springiness. Low springiness results in little chewiness. Chewiness is defined as the energy required to masticate solid food to a state of readiness for swallowing (Karaoglu and Kotancilar, 2009). The chewiness value of five cake samples were varied from 1.49 N.mm to 2.63 N.mm. From the data obtained, it shows that the varying amount of eggs used slightly affect the value of chewiness. Sample D show the lowest value of chewiness compared to other samples. Since no egg was presented, sample D lacked elasticity and therefore required less energy to chew. This relates to its lowest firmness value. However, chewiness is most difficult to measure precisely, because mastication involves compressing, shearing, piercing, grinding, tearing, and cutting along with adequate lubrication by saliva at body temperatures (Bhale S.D, 2004).

Chewiness is highly associated with firmness (Rahmati and Tehrani, 2014). A plot of chewiness as a function of firmness (Figure 4.3) with R^2 value of 0.7809 confirms the positive correlation between firmness and chewiness. Similar result was reported by Gomez et al. (2007) who stated that chewiness is a parameter dependent on firmness.

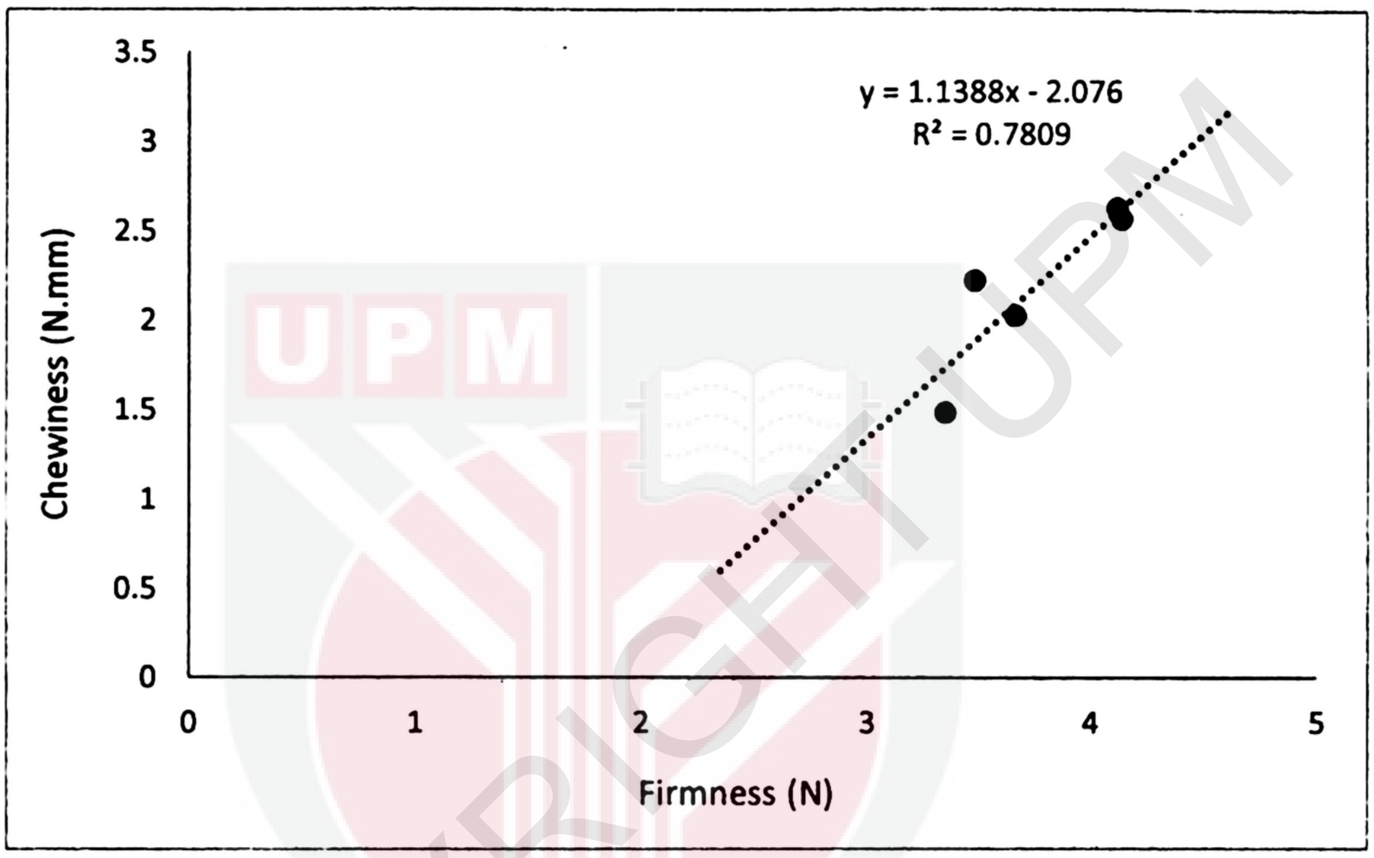

Figure 4.3: Chewiness is highly correlated with firmness

There was no statistical difference among the data obtained for springiness and cohesiveness of samples and all samples showed satisfactory springiness and cohesiveness values. Cohesiveness means the ability of the material to stick to itself. All samples showed comparable cohesiveness values ranging from 0.61 to 0.69. Control sample showed the highest value of cohesiveness as it contained the highest amount of eggs. This is expected for the control sample due to the availability of eggs to hold and retain the structure of cake during the baking and cooling process.

4.2.3 Sensory Evaluation

Sensory evaluation had been carried out based on research methodology. The spider web chart for sensory evaluation had been plotted as shown in figure 4.4. Capital A represent cake produced from melted ice cream with three eggs, B displayed cake produced from melted ice cream with two eggs, C is cake produced from melted ice cream with one egg, capital D shows a cake produced from melted ice cream with no egg and E is the control sample.

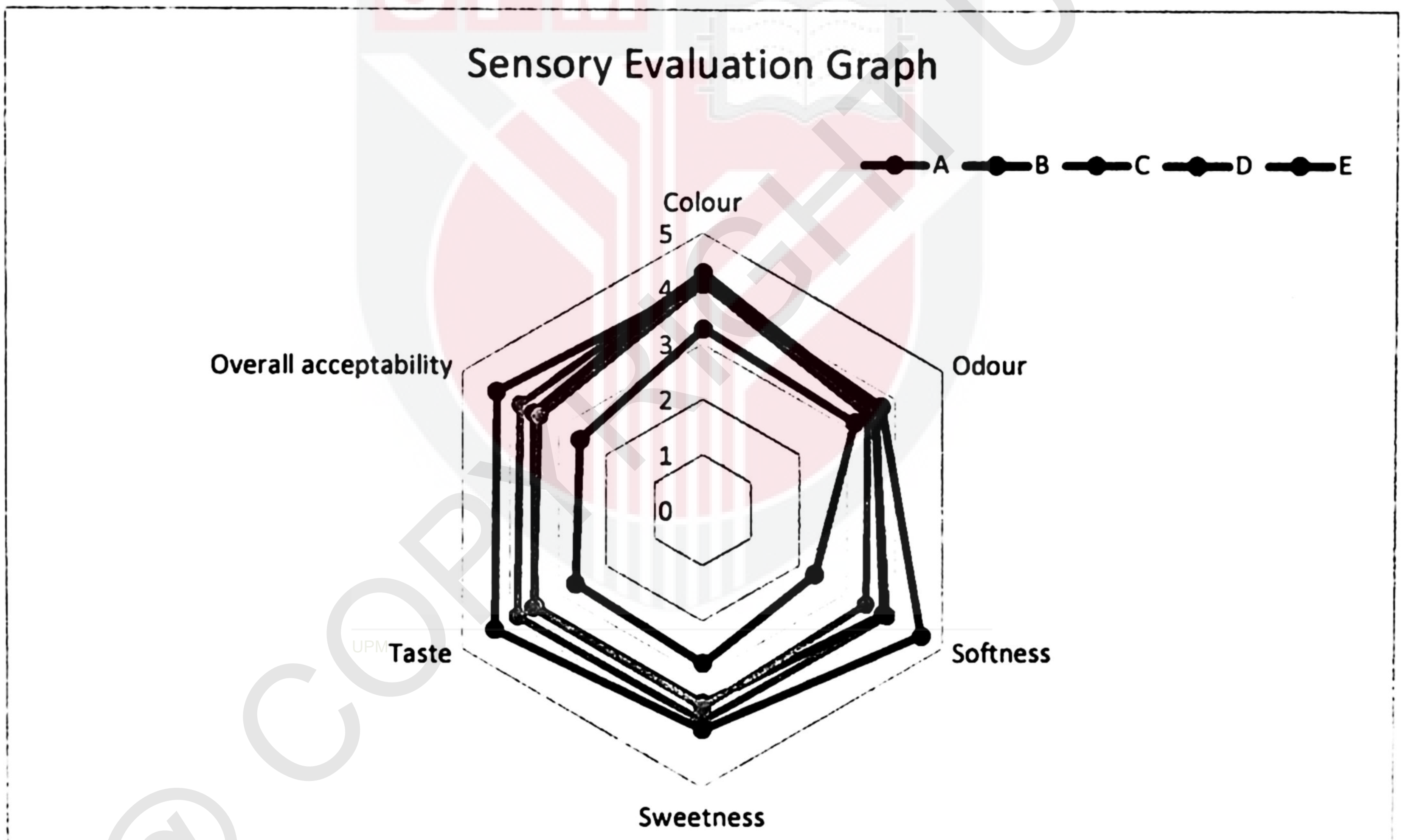

Figure 4. 4: Sensory evaluation chart

Colour, odour, softness, sweetness, taste, and overall acceptability of control sample and cake produced from melted left-over ice cream were evaluated, and the results are presented in figure 4.4.

According to the result obtained, the control sample had a maximum overall acceptability. The control sample also obtained the highest scores for odour, softness, sweetness and taste. This preference by the volunteers reflected the physical and texture quality that the sample possessed.

Sample D had the lowest score of overall acceptability (2.56). This was expected due to its lower score of taste (2.64) and softness (2.32) compared to the other cake samples. Besides, the volunteers found that the texture of sample D cake was sticky and fragile to touch. The absence of eggs in the formulation contributes to the least favorable quality due to the low content of emulsifier in the cakes. Sample A earned second highest overall acceptability representing its highest score on color (4.28) and great score on other criteria (>3.5). Sample B and C had acceptable qualities with scores >3.0 for each criterion. This shows that cake made using melted left-over ice cream has high acceptance quality (except for the eggless formulation). From the data on physical, texture, and sensory qualities, it can be seen that melted left-over ice cream can replace butter and be the source of emulsifier and liquid (that forms batter) in cake formulation.

CHAPTER 5 : CONCLUSION AND RECOMMENDATION

This chapter summarize the research work done. The main objective about this study is to determine and compare the viscosity of the ice cream mix (after 'ageing' process) and melted left-over ice cream. The physical characteristics of the cake such as moisture, volume index, contour and symmetry index and density and specific volume also was identified with varying the amount of eggs in the cake formulation which significantly influence the texture of the cake. Besides, texture analysis is conducted to determine the firmness, springiness, chewiness and cohesiveness of the cake. Sensory evaluated also was conducted to obtain the most preferred cake chosen by the volunteer. Not only that, recommendation for future work also given in this chapter.

5.1 Conclusion

Ageing is one of the important process in the manufacturing of ice cream where the network structure of ice cream is build which will greatly give an improve of texture, smoothness, and stability of the final ice cream. Freezing process is also important in the production of ice cream as it is one of the significant processes that influence the ice cream's viscosity. Ice cream known as one of the food material that have a complex multi-phase system and very sensitive to temperature. The structure of ice cream starts to break and collapse once it was exposed to the surrounding (warm environment). This phenomena causing the changes of viscosity between ice cream mix (after 'ageing' process), soft ice cream and melted ice cream. Thus, this research was conducted to determine and compare the viscosity of the ice cream mix (after 'ageing' process) and melted ice cream.

Left-over ice cream from ice cream production has a high potential to be converted into a value-added product which is a cake. Four suggested formulation of cake produced from melted left-over ice cream by varying the amount of eggs were conducted in this study. The ingredient used were instant cake mix, melted left-over ice cream and eggs. Conventional cake mix without the addition of melted ice cream was used as a control sample in this study. Therefore, the analysis on the sample cakes was conducted to identify the physical characteristics and textural profile, and evaluated the sensory characteristics for each of the cake.

The first objective to determine the viscosity of ice cream mix (after 'ageing' process) and melted left-over ice cream has been achieved as the result shows that there is a different value of viscosity between ice cream mix (after 'ageing' process) and melted left-over ice cream. The value of viscosity for melted left-over ice cream is higher than the ice cream mix (after 'ageing' process) where it shows that the melted left-over ice cream is more viscous even the structure of the ice cream already collapse.

The second objective is to identify the physical characteristics, textural profile, and sensory evaluation of the cakes. From the result obtained, we were able to innovatively re-formulate left-over ice cream to be converted into cake. The formulation allows butter and water to be eliminated, since the melted left-over ice cream already contributes to the batter's fat and water content. Eggs are required to be added in the formulation as the amount of emulsifier in the melted left-over ice cream is not high. The formulated cake has good moisture content as the melted ice cream contains stabilizer that helps to bind water and retain moisture. From the sensory evaluation, the formulated cake produced received a positive feedback and acceptance level as rated by the volunteers. This would be beneficial to any ice cream business to expand their ice cream-based product by innovatively reusing the by-product or left-over off the processing or selling stage.

To summarize, the objective for this project is achievable as we can see the left-over ice cream is able to be converted into a cake by varying the amount of eggs.

5.2 Recommendations

There are no other research conducted on the conversion of by-product from ice cream manufacturing into other food product which would lead to possible profit gain to the business. Many factors can affect the characteristics of the cake produced from melted left-over ice cream.

For the future research, instead of varying the amount of eggs, the amount of melted left-over ice cream in the formulation also can be varied as to improve the taste and structure of the cake. Besides, the project can be improved by varying the temperature and period of baking process in order to get the optimum baking conditions for cake produced from melted left-over ice cream. Nutritional value for cake produced from melted ice cream also can be add on as to ensure the cake produced from melted ice cream meet the human's need for their health. Lastly, other test should be done in order to get the specific result of the physical characteristic of ice cream such as the ice crystal test, test for the fat globule size and the air bubble size test. Therefore, many recommendation can be applied to study more about the characteristics of ice cream and cake produced from melted ice cream.

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