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EFFECTS OF PROCESSING PARAMETERS ON THE PHYSICAL AND TEXTURAL QUALITY OF ICE CREAM WAFER CONE

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ABSTRACT

An ice cream cone usually made of a wafer similar in texture to a waffle. The ice cream cone has made people convenient to enjoy the global favorite snack which is ice cream without need bowl or spoon. The quality of wafer is mainly controlled by flour property, water level and temperature, mixing action, baking time and temperature. The quality is judged by attributes of the batter such as the density, viscosity, holding time and temperature, and by properties of the wafer such as weight, surface colour, fragility and moisture content. Thus, this study was done to study the effect of water temperature on the batter and the effect of baking temperature and time on the ice cream wafer cone qualities. The temperature of water used in this study were 14, 20 and 26°C which were named as Sample 1, Sample 2 and Sample 3 respectively. The batter analysis was done in terms of determining the density and viscosity of the batter. Then, each sample of batter mixture was baked at a different temperature which were 150, 160, 170 and 180 °C with a different baking time of 3, 4 and 5 minutes. The baked ice cream wafer cone were analysed in terms of quality properties such as textural analysis (hardness, brittleness, toughness and crispiness), moisture analysis and colour analysis. Lastly, the quality parameters of the ice cream wafer cone will be compared to the quality parameter of the commercial ice cream wafer cone. By changing the water temperature, the viscosity of the batter mixture was affected where the batter mixture with high water temperature resulted in more viscous batter. The viscosity of the batter of water temperature at 14, 20 and 26°C were 1.06, 1.15 and 1.25 Pa.s. Density was not affected by changing the water temperature of the batter. The ice cream wafer cone baked at a higher temperature which was 180°C for 5 minutes resulted in a hard texture of ice cream wafer cone. The higher the viscosity of the batter mixture, the harder the texture

of the ice cream wafer cone would be. Sample 3 which used the water temperature at 26°C resulted in hardest texture of the cone where the ice cream wafer cone need higher force to break the ice cream wafer cone was 1029.17 g where the Sample 1 which used water temperature at 14 °C and the Sample 2 which used the water temperature at 20 °C were only needed smaller force to break the ice cream wafer cone which were 666.46 and 851.95 g respectively. When the ice cream wafer cone were baked at a higher temperature for a longer time, the moisture content of the ice cream wafer cone would be. The moisture content of the ice cream wafer cone baked at 180°C for 5 minutes has the lowest moisture content compared to the ice cream wafer cone baked at 180°C for 3 and 4 minutes. The moisture content of ice cream wafer cone baked for 3, 4 and 5 minutes were 2.75, 1.98 and 1.52% respectively. Hence, the ice cream wafer cone of Sample 2 bake at 160°C for 4 minutes have the quality properties near to the quality properties of commercial ice cream wafer cone.

ABSTRAK

Kon ais krim biasanya dibuat daripada wafer yang mempunyai tekstur yang sama seperti wafel. Kon ais krim memudahkan orang untuk menikmati makanan ringan kegemaran dunia iaitu ais krim tanpa menggunakan mangkuk atau sudu. Kualiti wafer dikawal terutamanya oleh sifat tepung, paras air dan suhu, tindakan pencampuran, masa pembakaran dan suhu. Kualiti dinilai oleh atribut adunan seperti ketumpatan, kelikatan, masa dan suhu pegangan, dan sifat wafer seperti berat, warna permukaan, kerapuhan dan kandungan lembapan. Oleh itu, kajian ini dilakukan untuk mengkaji kesan suhu air pada adunan dan kesan suhu pembakaran dan masa pada kualiti kon wafer ais krim. Suhu air yang digunakan dalam kajian ini ialah 14, 20 dan 26°C yang dinamakan sebagai sampel 1, sampel 2 dan sampel 3. Analisis adunan dilakukan dari segi menentukan ketumpatan dan kelikatan adunan. Kemudian, setiap sampel campuran adunan dibakar pada suhu yang berbeza iaitu 150, 160, 170 dan 180 °C dengan masa pembakaran yang berbeza iaitu 3, 4 dan 5 minit. Kon wafer ais krim yang telah dibakar telah dianalisis dari segi sifat-sifat berkualiti seperti analisis tekstural (kekerasan, kelembutan, kekerasan dan kerangupan), analisis kelembapan dan analisis warna. Akhir sekali, parameter kualiti kon wafer ais krim akan dibandingkan dengan parameter kualiti kon wafer ais krim yang komersial. Dengan mengubah suhu air, kelikatan campuran adunan telah terjejas di mana campuran adunan dengan suhu air yang tinggi menghasilkan adunan yang lebih likat. Kelikatan adunan suhu air di 14, 20 dan 26°C adalah 1.06, 1.15 dan 1.25 Pa. Ketumpatan tidak terjejas dengan mengubah suhu air adunan. Kon wafer ais krim yang dibakar pada suhu yang lebih tinggi iaitu 180°C selama 5 minit menyebabkan tekstur yang keras pada kon wafer ais krim. Semakin tinggi kelikatan campuran adunan, semakin keras tekstur kon wafer ais krim. Sampel 3 yang menggunakan suhu air pada suhu 26°C menghasilkan tekstur kon yang paling

keras di mana kon wafer ais krim memerlukan daya yang lebih tinggi untuk memecahkan kon wafer ais krim adalah 1029.17 g di mana Sample 1 yang menggunakan suhu air pada suhu 14 °C dan Sampel 2 yang menggunakan suhu air pada 20 °C hanya memerlukan kekuatan yang lebih kecil untuk memecahkan kon wafer ais krim yang masing-masing adalah 666.46 dan 851.95 g. Apabila kon wafer ais krim dibakar pada suhu yang lebih tinggi untuk masa yang lebih lama, kandungan lembapan kon wafer ais krim akan menjadi. Kandungan kelembapan kon wafer ais krim yang dibakar pada 180°C selama 5 minit mempunyai kandungan kelembapan yang paling rendah berbanding dengan kon wafer ais krim yang dibakar pada suhu 180°C selama 3 dan 4 minit. Kandungan lembapan kon wafer ais krim yang dibakar selama 3, 4 dan 5 minit masing-masing ialah 2.75, 1.98 dan 1.52%. Oleh itu, Sample 2 kon wafer ais krim yang bakar pada 160°C selama 4 minit mempunyai ciri-ciri yang berkualiti berhampiran dengan sifat-sifat kualiti kon wafer ais krim komersial.

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CHAPTER 1: INTRODUCTION

1.1 Background research

Eating ice cream has become a way of life for individuals connected with holidays, fairs, birthday parties and good life happiness. A good ice cream companion is definitely the cone that works with it. An ice cream cone with a different name such as poke or cornet is basically a dry, cone-shaped pastry, generally made of a wafer comparable to a waffle texture. The ice cream cone has created it easy for individuals to enjoy the world's favourite ice cream snack without needing a bowl or spoon. While sitting or moving, they can enjoy ice cream. Not to mention, the ice cream cone is edible. Thus, in a single bite, the consumer can appreciate the creamy and fresh flavour of ice cream and also the crunchiness of the cone. Ice cream cone comes in three different types: cake or ice cream wafer cone, waffle cone and a sugar cone (Wang, 2015).

As for ice cream cone making, it is created by a baking batter in the form of flat waffles and then rolled in conical shapes while still hot and flexible, enabling it to cool and to harden before lastly packaging (Huang, 1981). In the baking of ice cream cone, the ingredients in the batter commonly consist of flour, sugar, shortening, emulsifier and other minor ingredients (Huang, 1981). The flour used in the ice cream cone can be found in many distinct forms, including wheat flour, corn starch and tapioca starch. The cone flours used most of the time are soft wheat.

In the context of food texture, it is considered very crucial to consumers. The perception and enjoyment of food quality as taste can give a direct impact on the manner in consumers' mastification (Chenn,2009). Texture also one of the features used by consumers to evaluate food quality (Day & Golding, 2016).

1.2 Problem statement

The quantity of ingredients used to make ice cream cone can contribute to the texture of the product. The texture is a very important sensory property that impacts food stability and consumer choices. Wafer quality is controlled mainly by flour properties, water level and temperature, mixing action, baking time and temperature. Quality is assessed by the batter's attributes such as density, viscosity, time and temperature holding, and the wafer's properties such as weight, surface colour, fragility and moisture content. This research was therefore conducted to study the impact of water temperature on batter evaluation and the impact on ice cream wafer cone evaluation of baking temperature and time.

1.3 Objectives

This objective of the study were:

1. to study the effect of water temperature on batter analysis.
2. to study the effect of baking temperature and time on ice cream wafer cone analysis.

1.4 Research scopes

This study is divided into two main parts. The first part of was to study the effect of temperature on batter analysis. In this part, the ingredients were mixed together by using different temperature of water at 14, 20 and 26°C. The batter is then being analysed in order to determine the density and the viscosity of the batter of different temperature.

The second part of this study was to study the effect of baking temperature and time on ice cream wafer cone analysis. In this part, the batter will be baked at different temperature which were 150, 160, 170 and 180°C for about 3, 4 and minutes for each sample. The ice cream wafer cone will be analysed in terms of textural properties which is in determining the value of hardness, brittleness, toughness and crispiness of the ice cream wafer cone. Also, the moisture content and the colour of the ice cream wafer cone will be analysed.

CHAPTER 2: LITERATURE REVIEW

2.0 Introduction

Wafer cones are light, smooth and slightly sweet. A mix, similar to cake batter, is developed to create the model cake cone with the correct combination of flours, sugar, and shortenings. Made with pastry, cake and tapioca flours, these cones are the perfect blend of sweet and crispy to create a delicious counterpart to the ice cream.

Many factors, including flavor, body and texture, melting quality, colour, packaging, appearance and quality effect, the overall customer acceptance of the product.

2.1 Effect of ingredients

2.1.1 Viscosity of the batter mixture

According to Huber and Schoelenchner (2016), uses of wheat flour in batter ingredients can lead to an unstable batter if a powerful network of gluten is created. The protein-forming gluten network can lead to mechanical stability, but if it is too strong, it can lead in high batter viscosity. The addition of starch is another way to dilute the quantity of gluten.

Corn flour can improve rheological characteristics, water binding, and dough and batter gelatinization (Tegge, 2004). Corn starch in batter can be generated with more ordered batter microstructure as a result of rising in gelatinization enthalpy (Guadarrama-Lezama et al., 2016).

Shortening operates by contributing to the breakage in the gluten network. The fats will cover the proteins and starch granules and then lead to the breaking continuity of the protein and starch composition (Ghotra et al., 2002). It thus decreases the retrogradation of starch in baked goods. According to Huang (1981), shortening function is an obstacle against excessive gluten growth that can result in bad eating quality in a difficult texture cone.

2.1.2 Texture of the ice cream wafer cone

Cereal, tuber and root starches are mainly used as stabilizers or texture modificators in the food sector (Mishra & Rai, 2006). Starch also considerably adds to the texture characteristics of many foods such as thickeners, colloidal stabilizers, gelling agents, bulking agents and water retention agents (Singh et al., 2007). Starch can impart textural and general acceptability based on its nutritional importance. Crispiness is also favorably associated with starch amylose content (Mohamed et al., 1998).

During batter mixing, fat can help in the aeration phase. For example, when adding oil to the batter, the batter's consistency will smooth out and create a crunchy coating on the outside of the wafer. The function of shortening in baked goods is to provide textural characteristics such as a brief bite, a lubricating moist texture and crispiness (Ghotra et al., 2002).

2.2 Effect of batter temperature

2.2.1 Viscosity of the batter mixture

According to Cauvain and Young (2009), the optimum battery performance and quality of the cake are accomplished by controlling batter temperatures when deposited. This is true if the batter includes chemical aerating agents like baking powder because the chemical reaction levels are susceptible to the temperature where the higher the temperature, the quicker the reaction. In the case of cake batters, enhanced baking powder reactivity results in the premature discharge of carbon dioxide gas that will be seen as a reduction in batter density and eventually a loss of the quantity of baked product. In batter recipes, the ratio of liquid to flour is much higher and therefore, a surfeit of material which can be used to adjust the batter temperature.

According to Dogan (2006), the temperature of water alters the viscosity of batter and affects the quality of the sheet. Water temperature should be around 20°C to prevent gluten strand formation. If the flour has a high a-amylase activity in warm conditions, the batter's viscosity falls rapidly. The water temperature for batter preparation should be constant at around 20–30 ° C, because the warmer the water, the thicker the batter (Tiefenbacher, 2009).

According to Guadarrama- Lezama et. al (2016), when the starch granules are heated in the water, some of the water is absorbed and then swells. As the temperature rises, the granules will continue to absorb more water until they achieve peak volume and viscosity. This process is called gelatinization temperature. The interaction between starch molecules and lipid appear to be an essential factor in modifying rheological and thermal behaviour of batter formulations.

2.2.2 Texture of the ice cream wafer cone

According to Launay (1979), doughs of the same consistency may have distinct viscosities and may behave differently in creep tests and sensory evaluations. Increased added water or temperature reduces dough consistency. However, according to Farahnaky and Hill (2007), added water softens the dough and reduces the hydration time and the mixing energy. Temperature increase had negative effect on consistency, hydration time and total energy.

2.3 Effect of baking conditions

2.3.1 Texture of the ice cream wafer cone

According to Cauvain and Young (2009), during wafer manufacturing process, there is no substantial degradation of starch molecules compared with other bakery products and extruded cereals. Therefore wafers comprise of two unique textural properties:

a. Extreme crispness on biting and initial chewing.

b. Good mouth feeling during prolonged chewing and swallowing owing to the absence of sticky, glutinous stimuli.

If at the moment of plate opening the wafer is not adequately dried out, the shrinking may not be adequate to allow the sheet to drop away. Conversely, if the drying is too much and some surface burning has occurred sticking may be experienced for this reason also. If the heat disposition across a plate is uneven, there may be cracks in the plate immediately opening the plate and before the sheet drops away.

According to Vieira and Takaki (2014), in the context of maximum bite force (MBF), it plays important role in this study since the produce baked wafer cone cannot exceed the value of MBF. MBF can be described as the maximum force on the fragmentation of food conducted by humans, which corresponds directly to the activity of mastication. The chewing activity is affected by the food's consistency.

2.3.2 Moisture content of the ice cream wafer cone

After baking, the residual moisture is 0.8-1.5%. As both the water activity of the air in the production area and the water activity of the air in the production area and the water activity of filling creams or coatings are well above that, wafers pick up moisture very easily. The sheet sizes improve by 0.2-0.3 % for every 1% of extra moisture in line with this sorption. This can result in cracking of the coating in enrobed wafer biscuits. To compensate for low water activity, humidity conditioning up to 4.5% wafer moisture is possible. In addition, with increasing water activity, the wafer texture changes from a soft to a harder crispness, followed by greater mechanical stability, which is useful for both handling and the final texture of the product. The wafer sheets maintain their typical crisp texture up to 5-6 % moisture content, but in most instances, greater moisture levels will result in inadequate, tough, or even soft and soft textures.

Table 2.1: Effect of water activity and moisture content on wafer texture

Wafer Condition	Water Activity	Moisture(%), approx	Wafer Texture
Freshly baked	<0.1	<2	Very tender, crisp
After conditioning	0.3	4.5	Crisp, harder
Limit of crispiness	0.5/0.55	≥6	Crisp to tough
Wafers, foam-filled	0.7	≥12	Soft to flexible
Collapse of structure	>0.85	>20	Very soft, shrinks

Water hardness had no effects on batter moisture and its water activity value. Only a small amount of research has been performed to explore the impact of various fat sources or leavening agents on the colour of the resulting bakery products, as opposed to the effect of different flours. Their contribution to browning due to Maillard reactions has been investigated by several researchers (Miller, 2016; Vetter, 2003). Also, the influence of water hardness is not well understood for bakery products, but it is well known that it can change the quality of distillates (Bringhurst & Brosnan, 2014). The phenomenon of changing waffle cohesion was observed during previous tests with wafers. Wafers produced with distilled water were far more crumbly brittle than wafers produced with water of 12°dH water hardness.

Higher water hardness influences waffle texture and may require a reduced amount of leavening agents. But hard water increases baking plate residues. Soft water provides smoother waffle texture, which decreases waffle stability. Stable waffles can be taken off easier (Tiefenbacher, 2009).

According to Huang et. al (1989), the mold growth on cones becomes a problem at a water activity >0.80. The original cone shape is distorted at water activities > 0.53 as a result of the cones absorbing moisture and becoming perceptibly soggy under extremes of humidity. The main consumer problem is cone crispness, which can be maintained by keeping water activity at 0.32 or less, corresponding to a maximum cone moisture content of 4.7%. The moisture absorption isotherm of cones at 20°C is shown in Figure 1.

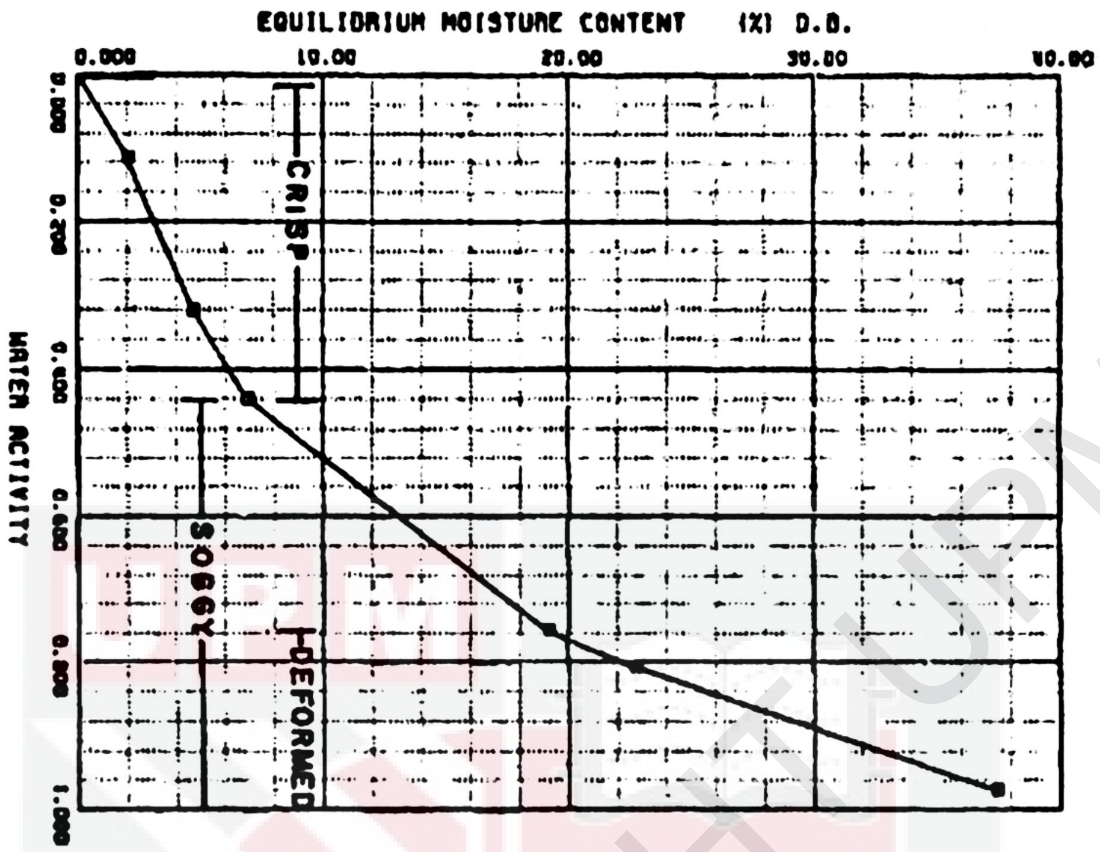

Figure 2.1: Moisture absorption isotherm of ice cream cones at 20°C

2.2 Colour of the ice cream wafer cone

According to Cauvain and Young, when most of the water is driven off, the glass temperature of the wafer matrix rises, resulting in a stable structure. The temperature of the wafer increases to 160-190°C. The Maillard reactions take place at this point, resulting in typical wafer colour and flavour formation. The baking times are between 1.5 and 2.5 min, depending on the wafer thickness and baking temperature.

CHAPTER 3: METHODOLOGY

3.1 Introduction

This chapter will describe in detail on the methods done and materials and equipment used throughout the experimental work. This chapter is divided into a few sections which are 3.2 – 3.9 where all the steps included in the experimental design of the study. Meanwhile, section 3.4 is on batter preparation steps, 3.5 is on batter analysis that includes the density and viscosity of batter determination, 3.6 is on determination of baking temperature and baking time, 3.7 is on texture analysis for the ice cream wafer cone, 3.8 is on moisture content analysis for the ice cream wafer cone and lastly, 3.9 is on the colour analysis for the baked ice cream wafer cone.

3.2 Experimental design

Figure 3.1 shows the process flow of the experimental design for this study. Wet ingredients such as water and albumen were measured first into a bowl. Then, the dry ingredients were added one by one after being measured. After that, the mixture was stirred first by using a spoon and then the mixing activity was done by using a hand mixer at the lowest speed until all ingredients were all mixed to form a batter. After that, the analysis of the batter in terms of the density and viscosity were done. Then, the batter were baked at different baking condition and the properties of the baked ice cream wafer cone were analysed in terms of the texture, moisture and colour. Lastly, the properties of baked ice cream wafer cone were compared to the commercial ice cream wafer cone.

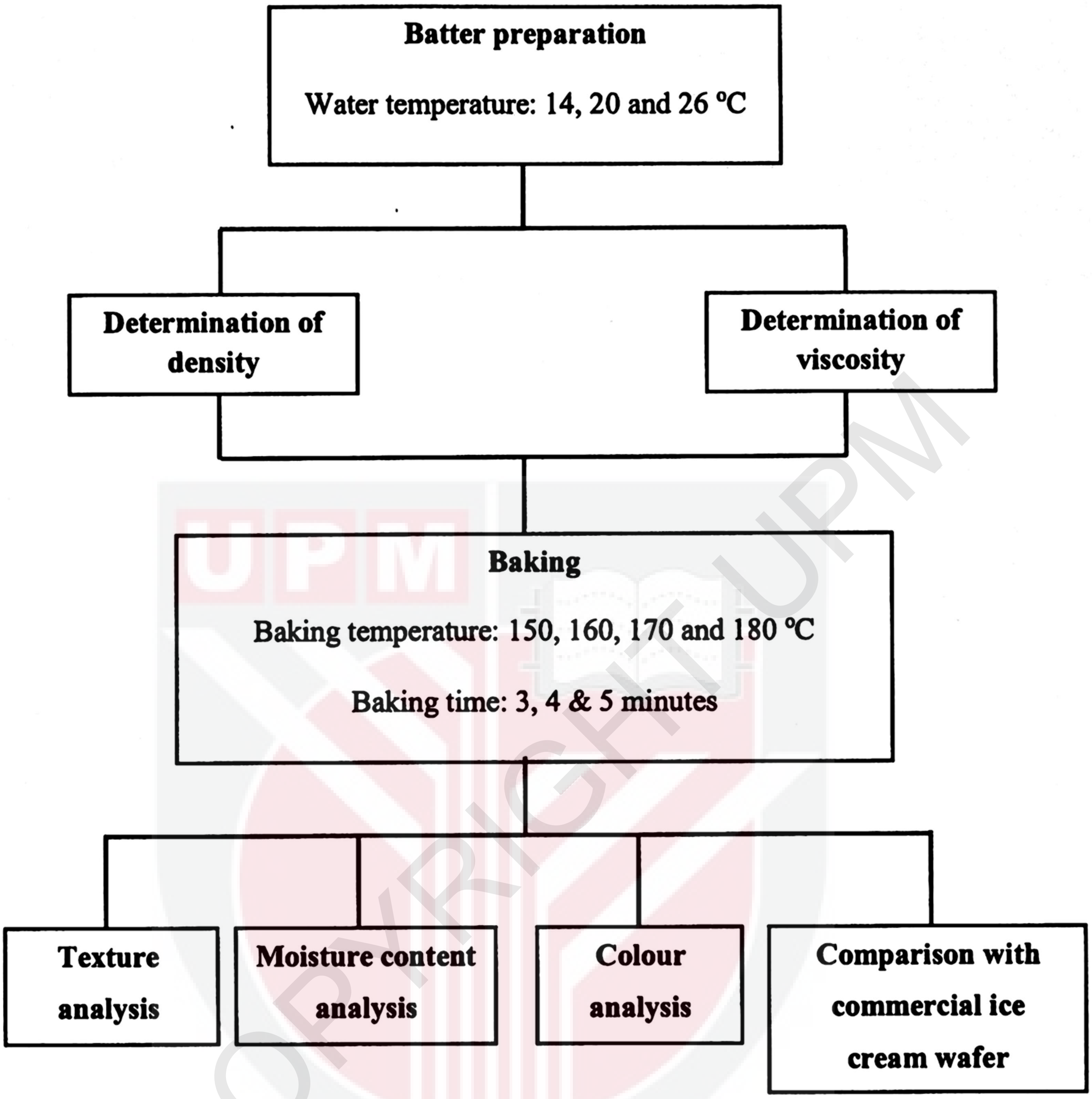

Figure 3.1: The block flow diagram of the experimental work

3.3 Material selection

The ingredients that have been used in the batter preparation were 52.48% of water, 34.85%t of wheat flour, 10.02% of tapioca starch, 0.01% of sugar, 0.006% of sodium bicarbonate, 0.004% of salt and 0.004% of albumen. All the wet ingredients had been purchased from the grocery shop in Sri Serdang.

As for the control recipe which was commercial ice cream wafer cone, it has been purchased from a fast food franchise in Sri Serdang.

3.4 Batter preparation

Wet ingredients such as water and albumen were measured first into a bowl. Then, the dry ingredients were added one by one after being measured. After that, the mixture was stirred first by using a spoon and then the mixing activity was done by using a hand mixer at the lowest speed until all ingredients were all mixed to form a batter.

Figure 3.2: The batter mixture

3.5 Analysis conducted on the batter mixture

The parameters involved in the batter analysis were density and viscosity of the batter. The analysis was done immediately after the batter mixing activity is done.

3.5.1 Density of the batter

The material used to determine the value of the batter density was density weight (Model: Mettler Toledo Brand, Swiss). The density weight needed to be set up by choosing the setting of measuring the density. The batter was then put into the beaker until the sinker sink in the batter. The measuring balance displayed the value of the density when the measuring process stop. The analysis was done in triplicate.

Figure 3.3: Determination of batter density

3.5.2 Viscosity of the batter

The material used to determine the value of the batter viscosity was rheometer (Model: TA-XT Plus Texture Analyzer, United States). The parameters of the batter had been set up in the software and the batter was put on the peltier plate. The reading started when the geometry achieved a distance of 30μm from the peltier plate.

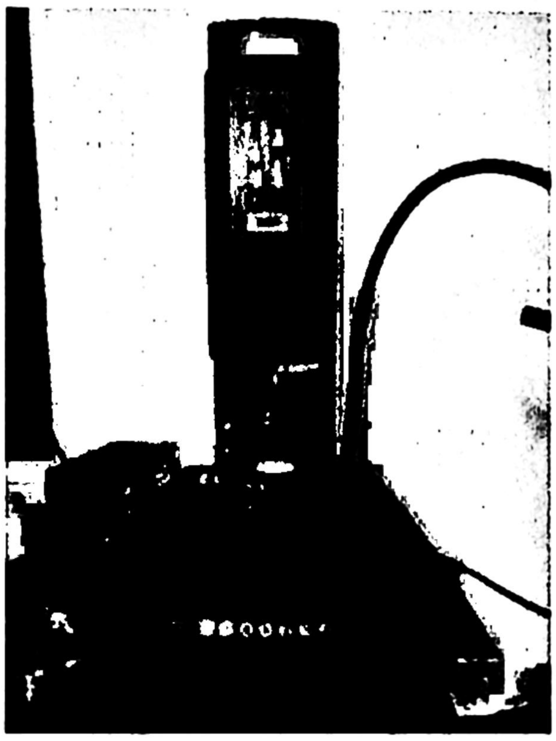

Figure 3.4: Determination of batter density

3.6 Selection of the baking time and temperature

The selection of baking time was based on the previous study of Kigozi et al. (2014) and Cauvain and Young (2015). The baking time has been decided on 3 different durations, which were 3 minutes, 4 minutes and 5 minutes since the value in the journal is in the range of 1.5 - 6.5 minutes. As for temperature of the baking, an optimization was done first for temperature of 150, 160, 170 and 190°C at 3 different baking times as stated as before.

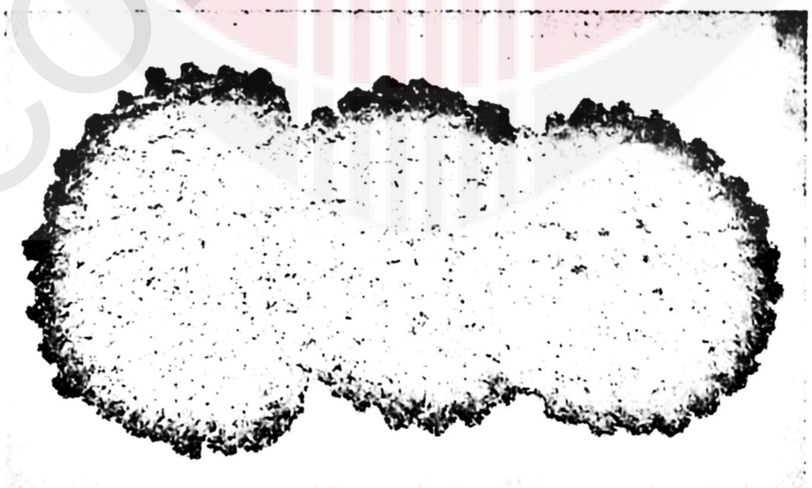

Figure 3.5: Determination of baking temperature and time

Figure 3.6: Ice cream wafer cone maker

3.7 Texture analysis

The texture analyzer equipment (Model: TA – XT plus, Stable Micro Systems Brand, United States) was used in this study to measure the hardness, brittleness, toughness and crispiness of the ice cream wafer cone. The texture analyzer was calibrated by putting a 25 kg load cell. The texture of the ice cream wafer cone were analysed by using a cylindrical probe (P/2) of 2 mm diameter.

Figure 3.7: Texture determination

Table 3.1: The properties description in texture analysis

Properties	Description
Hardness	The distance the probe moves and the force required to break the ice cream wafer cone
Brittleness	The distance at the maximum force
Toughness	Area to the maximum force
Crispiness	Number of fracture peaks occurring during the test

3.8 Moisture content analysis

The equipment used was moisture analyzer (Model: AND MX-50, Swiss) in order to measure the moisture content of the ice cream wafer cone. The ice cream wafer cone was weighed until it reached 2 g of weight by using a measuring balance. Then, the sample was placed inside the aluminium plate and straight away put into the moisture analyzer. The analysis was done in triplicate.

Figure 3.8: Determination of moisture content

3.9 Analysis of colour

The equipment used for the analysis was a colour reader (Model: UltraScan Pro, HunterLab, United States). The method used was the CIE L^*, a^* and b^* colour scale. The parameters determined were L^* ($L^* = 0$ (black) and $L^* = 100$ (white)), b^* (negative values correspond to blueness and positive values correspond to yellowness) and a^* (negative values correspond to greenness and positive values correspond to redness). The analysis was done in triplicate at room temperature. The value of the total colour difference was measured by using the equation below.

$$\Delta E = \sqrt{((L^* - L)^2 + (a^* - a)^2 + (b^* - b)^2)}$$ Equation 3.1: Total Colour Difference

Figure 3.9: Determination of colour

CHAPTER 4: RESULT AND DISCUSSION

4.1 Introduction

This chapter explains on the results obtained from the experimental work and discussion on the results. This chapter is divided into a few sections which are sections 4.2- 4.6. Each section explains on all of the analysis as listed in Figure 1 whereas section 4.6 summarizes all the discussions that had been made.

4.2 Analysis of batter

Based on Table 4.1, the temperature of the water that has been chosen were 14, 20 and 26°C. The interval between the temperature of water chosen was slightly bigger in order to find the significant effects towards the ice cream wafer cone. According to Huber et al. (2016), the suitable batter temperature should be in the range between 21.0 to 26.6°C. However, according to Dogan (2006), the water temperature should be around 20°C to prevent gluten strand formation since the temperature of water alters the viscosity of batter and affects the quality of the sheet.

The density of the batter was almost the same even though the temperature of the water used were not the same which were 14, 20 and 26°C and the density of the batter for different temperature were 1.181, 1.204 and 1.196 g/ml respectively. The density and viscosity of the batter play an important role in the effects of fluidity properties of batters and the outcome quality of baked wafer sheet. Depending on gluten level added to the flour and water level in the formula, temperature and mixing time, variation in the density could be expected. A good fluidity behaviour should have density value in the range of 0.8 to 0.95 g/ml (Huber et al., 2016). However, according to Wade (1988), the average density of batter temperature between 1.14 to 1.15 g/ml. In wafer production, the batter density should be in a narrow range because the batter was volumetrically deposited on the baking plate. Thus, the density of the batter used to have a good fluidity since they have almost the same value of density stated by Wade (1988).

The viscosity of the batter which used the water at 14°C has higher viscosity compared to the viscosity of the batter that uses the temperature of water at the 20 and 26°C. The viscosities of the batter at different temperature of water used were 1060, 1150 and 1250 cP. According to Tiefenbacher (2017), the typical range of the viscosity of the batter were 250-1200 cP. In warm conditions, the viscosity of the batter quickly drops due to the temperature of the batter. At warm condition, the batter tends to form clump that will result the batter to have a higher viscosity. This will affect the ice cream wafer cone quality since it will make the ice cream wafer cone not uniformly baked. Hence, the batter viscosity of the batter used were favourable since it has the typical batter viscosity in the industry.

Table 4.1: Batter parameters

Samples	Temperature of water, °C	Density, g/ml	Viscosity, Pa.s
Sample 1	14	1.181	1.06
Sample 2	20	1.204	1.15
Sample 3	26	1.196	1.25

4.3 Textural analysis

4.3.1 Effect of baking temperature and time on hardness

Based on Figure 4.1, the hardness of the ice cream wafer cone of sample 1 which the batter was mixed with the water of 14°C baked for 3 minutes, the ice cream wafer cone baked at 160°C has the lowest force required in order to break the ice cream wafer cone compared to the ice cream wafer cone that has been baked at 150, 170 and 180°C. This was due to the amount of heat required for the ice cream wafer cone was enough to fully bake the ice cream wafer cone. Based on Appendix 1, the maximum force needed to break the ice cream wafer cone baked at 160°C for 3 minutes was 331.31 g while the maximum force needed to break the ice cream wafer cone at 150, 170 and 180°C were 523.12, 453.70 and 439.99 g respectively. The maximum force needed to break the ice cream wafer cone that has been baked at 150°C was higher compared to 160, 170 and 180°C because the ice cream wafer cone was not fully baked since the baking time was not enough for the ice cream wafer cone to be baked at 150°C.

The hardness of the ice cream wafer cone of sample 2 which the batter was mixed with the water of 20°C baked for 3 minutes, the ice cream wafer cone baked at 160°C has the highest force required in order to break the ice cream wafer cone compared to the ice cream wafer cone that has been baked at 150, 170 and 180°C. This was due to the amount of heat required for the ice cream wafer cone was enough to fully bake the ice cream wafer cone. Supposedly the force required by the ice cream wafer cone baked at 160°C should be lower compared to force required by the ice cream wafer cone baked at 170 and 180°C because the baking temperature was lower. The force required by the ice cream wafer cone baked at 160°C highest due to the unbaked ice cream wafer cone because the ice cream wafer cone's moulding was not fully hot to 160°C that resulted in the unbaked ice cream wafer cone. Based on Appendix 1, the maximum force needed to break the ice cream wafer cone baked at 160°C for 3 minutes was

655.51 g while the maximum force needed to break the ice cream wafer cone at 150, 170 and 180°C were 460.30, 466.82 and 563.21 g respectively.

The hardness of the ice cream wafer cone of sample 3 which the batter was mixed with the water of 26°C baked for 3 minutes, the wafer baked at 160°C has the lowest force required in order to break the ice cream wafer cone compared to the ice cream wafer cone that has been baked at 150, 170 and 180°C. This was due to the amount of heat required for the ice cream wafer cone was enough to fully bake the ice cream wafer cone. Based on Appendix 1, the maximum force needed to break the ice cream wafer cone baked at 160°C for 3 minutes was 575.8 g while the maximum force needed to break the ice cream wafer cone at 150, 170 and 180°C were 898.93, 695.17 and 962.24 g respectively. The maximum force needed to break the ice cream wafer cone that has been baked at 150°C was higher compared to 160, 170 and 180°C because the ice cream wafer cone was not fully baked since the baking time was not enough for the ice cream wafer cone to be baked at 150°C.

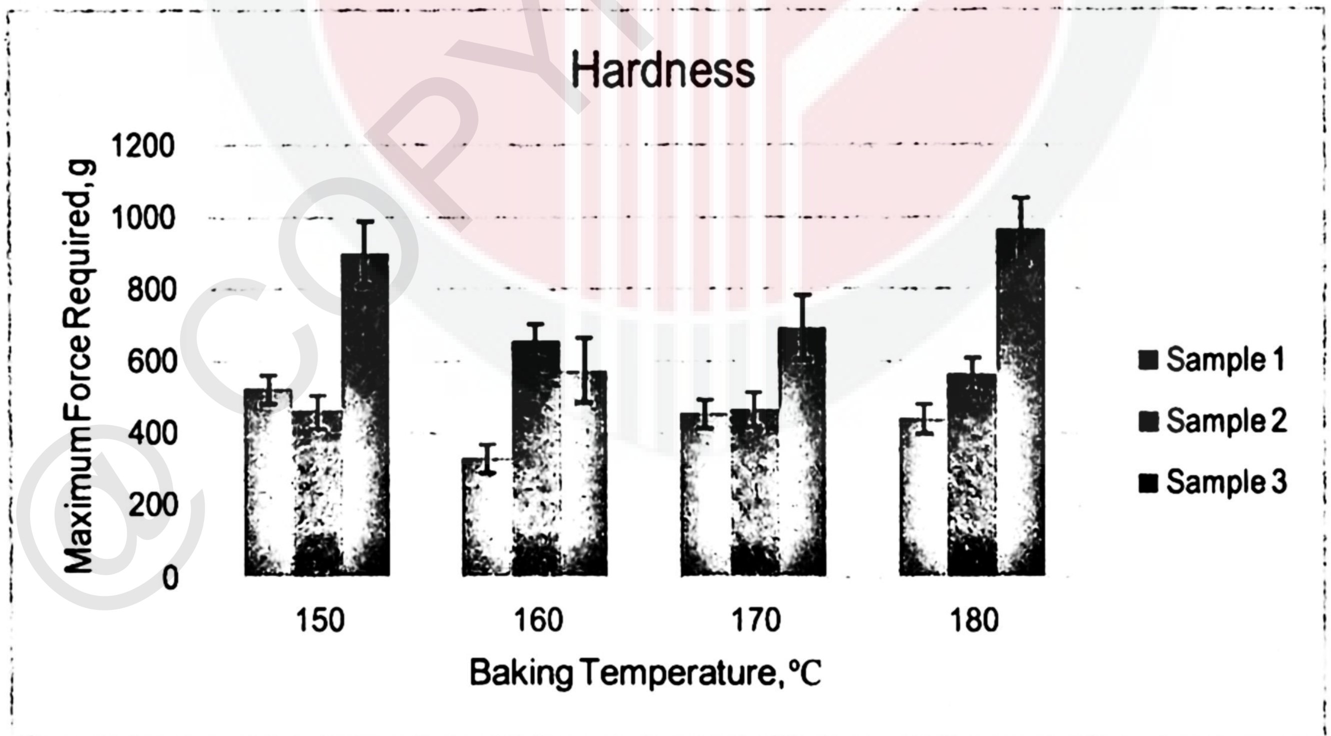

Figure 4.1: Graph of the hardness of ice cream wafer cone at different baking temperature and baking time for 3 minutes

Based on Figure 4.2, the hardness of the ice cream wafer cone of sample 1 which the batter was mixed with the water of 14°C baked for 4 minutes, the ice cream wafer cone baked at 170°C has the lowest force required in order to break the ice cream wafer cone compared to the ice cream wafer cone that has been baked at 150, 160 and 180°C. This was due to the amount of heat required for the ice cream wafer cone was enough to bake the ice cream wafer cone. Based on Appendix 1, the maximum force needed to break the ice cream wafer cone baked at 170°C for 4 minutes was 466.24 g while the maximum force needed to break the ice cream wafer cone at 150, 160 and 180°C were 650.02, 610.03 and 573.52 g respectively. The maximum force needed to break the ice cream wafer cone that has been baked at 180°C was higher compared to 150, 160 and 170°C because the ice cream wafer cone was overbaked since it was bake at a higher temperature for a long time. This will cause the ice cream wafer cone to be burnt and the texture will be harder.

The hardness of the ice cream wafer cone of sample 2 which the batter was mixed with the water of 20°C baked for 4 minutes, the wafer baked at 160°C has the lowest force required in order to break the ice cream wafer cone compared to the ice cream wafer cone that has been baked at 150, 170 and 180°C. This was due to the amount of heat required for the ice cream wafer cone was enough to bake the ice cream wafer cone. Based on Appendix 1, the maximum force needed to break the ice cream wafer cone baked at 160°C for 4 minutes was 382.57 g while the maximum force needed to break the ice cream wafer cone at 150, 170 and 180°C were 580.07, 510.30 and 657.75 g respectively. The maximum force needed to break ice cream wafer cone that has been baked at 180°C was higher compared to 150, 160 and 170°C because the ice cream wafer cone was overbaked since it was bake at a higher temperature for a long time. This will cause the ice cream wafer cone to be burnt and the texture will be harder.

The hardness of the ice cream wafer cone of sample 3 which the batter was mixed with the water of 26°C baked for 4 minutes, the wafer baked at 160°C has the lowest force required in order to break the ice cream wafer cone compared to the ice cream wafer cone that has been baked at 150, 170 and 180°C. This was due to the amount of heat required for the ice cream wafer cone was enough to bake the ice cream wafer cone. Based on Appendix 1, the maximum force needed to break the ice cream wafer cone baked at 160°C for 4 minutes was 606.37 g while the maximum force needed to break the ice cream wafer cone at 150, 170 and 180°C were 739.80, 744.56 and 1019.57 g respectively. The maximum force needed to break the ice cream wafer cone that has been baked at 180°C was higher compared to 150, 160 and 170°C because the ice cream wafer cone was overbaked since it was bake at a higher temperature for a long time. This will cause the ice cream wafer cone to be burnt and the texture will be harder.

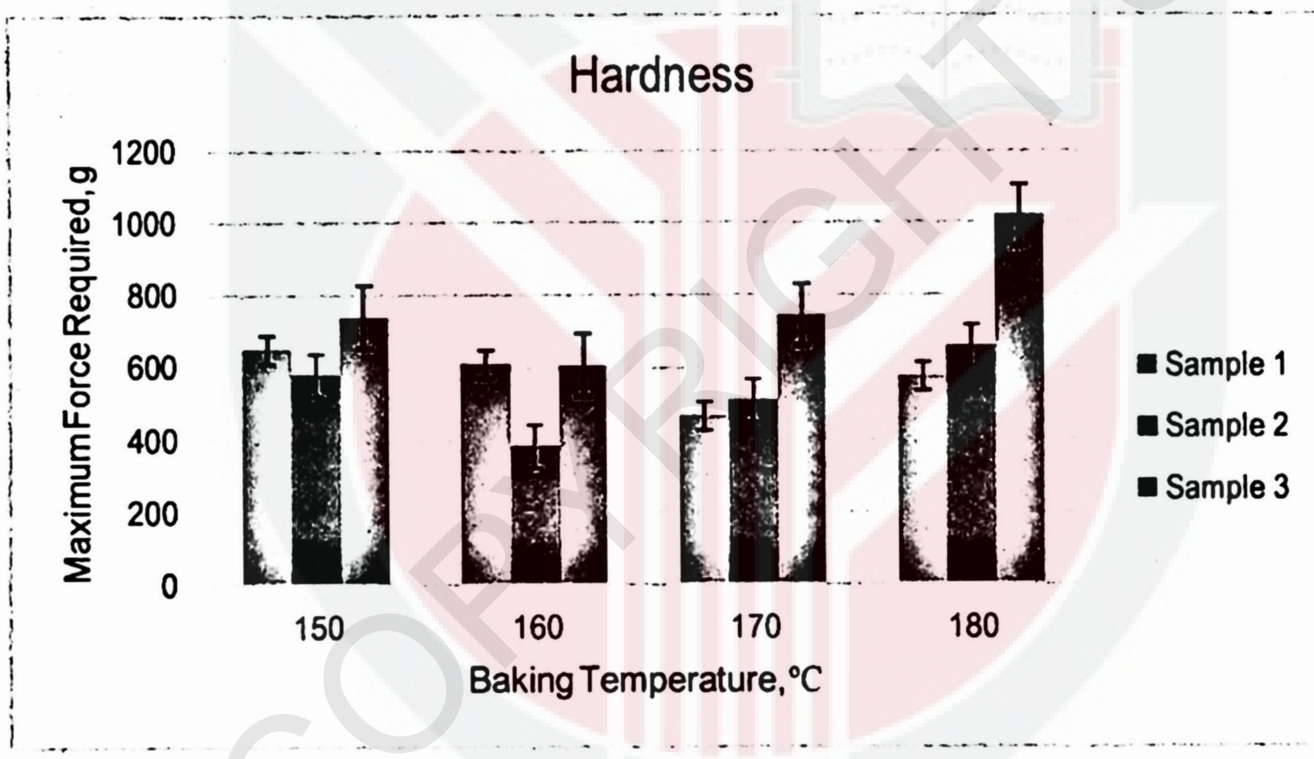

Figure 4.2: Graph of the hardness of ice cream wafer cone at different baking temperature and baking time for 4 minutes

Based on Figure 4.3, the hardness of the ice cream wafer cone of sample 1 which the batter was mixed with the water of 14°C baked for 5 minutes, the wafer baked at 150°C has the lowest force required in order to break the ice cream wafer cone compared to the ice cream wafer cone that has been baked at 160, 170 and 180°C. This was due to the amount of heat required for the ice cream wafer cone was enough to bake the ice cream wafer cone. Based on Appendix 1, the maximum force needed to break the ice cream wafer cone baked at 150°C for 5 minutes was

593.37 g while the maximum force needed to break the ice cream wafer cone at 160, 170 and 180°C were 627.62, 658.15 and 666.46 g respectively. The maximum force needed to break the ice cream wafer cone that has been baked at 160, 170 and 180°C was higher compared to 150°C because the ice cream wafer cone was overbaked since it was bake at a higher temperature for a long time. This will cause the ice cream wafer cone to be burnt and the texture will be harder.

The hardness of the ice cream wafer cone of sample 2 which the batter was mixed with the water of 20°C baked for 5 minutes, the wafer baked at 160°C has the lowest force required in order to break the ice cream wafer cone compared to the ice cream wafer cone that has been baked at 150, 170 and 180°C. This was due to the amount of heat required for the ice cream wafer cone was enough to bake the ice cream wafer cone. Based on Appendix 1, the maximum force needed to break the ice cream wafer cone baked at 160°C for 4 minutes is 472.89 g while the maximum force needed to break the ice cream wafer cone at 150, 170 and 180°C were 510.56, 676.25 and 851.95 g respectively. The maximum force needed to break the ice cream wafer cone that has been baked at 180°C was higher compared to 150, 160 and 170°C because the ice cream wafer cone was overbaked since it was bake at a higher temperature for a long time. This will cause the ice cream wafer cone to be burnt and the texture will be harder.

The hardness of the ice cream wafer cone of sample 3 which the batter was mixed with the water of 26°C baked for 5 minutes, the wafer baked at 150°C has the lowest force required in order to break the ice cream wafer cone compared to the ice cream wafer cone that has been baked at 160, 170 and 180°C. This was due to the amount of heat required for the ice cream wafer cone was enough to bake the ice cream wafer cone. Based on Appendix 1, the maximum force needed to break the ice cream wafer cone baked at 150°C for 5 minutes was 637.62 g while the maximum force needed to break the ice cream wafer cone at 160, 170 and 180°C was 867.73, 1027.20 and 1029.17 g respectively. The maximum force needed to break the ice cream wafer cone that has been baked at 160, 170 and 180°C was higher compared to 150°C because the ice cream wafer cone was overbaked since it was bake at a higher temperature for a long time. This will cause the ice cream wafer cone to be burnt and the texture will be harder.

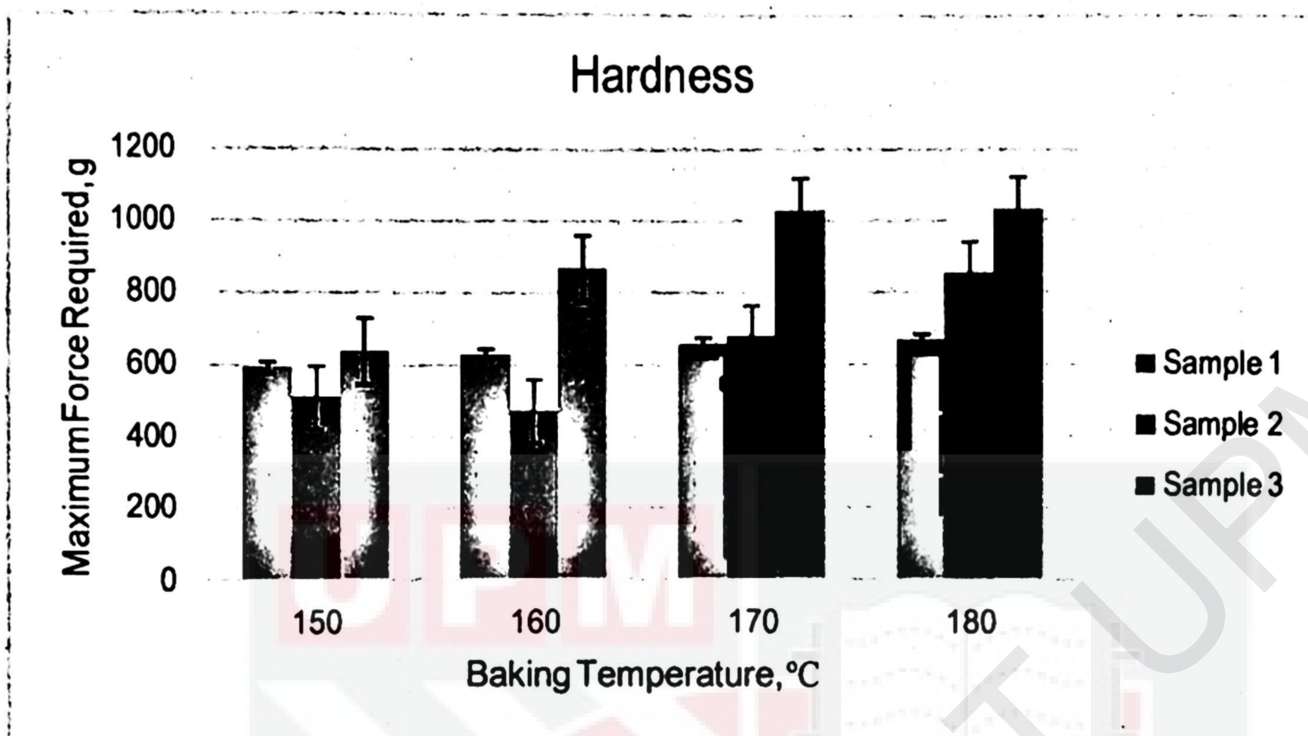

Figure 4.3: Graph of the hardness of ice cream wafer cone at different baking temperature and baking time for 5 minutes

4.3.1.1 Comparison between the samples and commercial ice cream wafer cone on the hardness

Comparing the result of the hardness of the ice cream wafer cone for Sample 1 which has used the temperature of water at 14°C and the hardness of commercial ice cream wafer cone, it can be conclude that the ice cream wafer cone bake at 160, 170 and 180°C for 3 minutes and the ice cream wafer cone baked at 170°C for 4 minutes has the value of maximum force needed by the ice cream wafer cone which was near to the value of the maximum force needed by the commercial ice cream wafer cone which was 397.05 g.

Comparing the result of the hardness of the ice cream wafer cone for Sample 2 which has used the temperature of water at 20°C and the hardness of commercial ice cream wafer cone, it can be conclude that the ice cream wafer cone bake at 150 and 170°C for 3 minutes and the ice cream wafer cone baked at 160°C for 4 and 5 minutes has the value of maximum force needed by the ice cream wafer cone which was near to the value of the maximum force needed by the commercial ice cream wafer cone which was 397.05 g.

Comparing the result of the hardness of the ice cream wafer cone for Sample 3 which has used the temperature of water at 26°C and the hardness of commercial ice cream wafer cone, it can be conclude that none of the ice cream wafer cone bake at 150, 160, 170 and 180°C for 3, 4 and 5 minutes has the value of maximum force needed by the ice cream wafer cone which was near to the value of the maximum force needed by the commercial ice cream wafer cone which was 397.05 g. Means that the temperature of water at 26°C was not suitable to be used to in making the ice cream wafer cone that has quality like commercial ice cream wafer cone.

Among the three different types of the sample that have different temperature of water, Sample 2 has the lower value of the force required by the ice cream wafer cone in order to break compared to Sample 1 and 3. According to Cauvain and Young if the wafer was not sufficiently dried out at the time of plate opening, the shrinkage may not be sufficient to allow the sheet easily to drop away. Conversely, if the drying was too much and some surface burning will occur. According to Dogan (2006), water temperature should be around 20°C to prevent gluten strand formation. The higher the temperature, the thicker the batter will be.

Table 4 2: Hardness of commercial ice cream wafer cone

	Hardness, g Average (±SD)
Commercial ice cream wafer cone	397.05 (±93.81)

4.3.2 Effect of baking temperature and time on brittleness

Based on Figure 4.4, the brittleness of the ice cream wafer cone of sample 1 which the batter was mixed with the water of 14°C baked for 3 minutes, the wafer baked at 160°C has the lowest value of brittleness compared to the ice cream wafer cone that has been baked at 150, 170 and 180°C. Based on Appendix 2, the value of brittleness for the ice cream wafer cone baked at 160°C for 3 minutes was 0.25 mm while the value of brittleness for the ice cream wafer cone at 150, 170 and 180°C were 0.39, 0.39 and 0.48 mm respectively. This can be seen that the ice cream wafer cone that has been baked at 160°C was not brittle as much as the ice cream wafer cone baked at 150, 170 and 180°C. This was due to the different amount of heat received by the ice cream wafer cone during baking where the ice cream wafer cone's moulding was not fully heated up to 160°C. As for the ice cream wafer cone that has been baked at 150°C, the ice cream wafer cone was brittle because the ice cream wafer cone was not fully baked due to the shorter time of baking at lower temperature while the ice cream wafer cone baked at 170 and 180°C were brittle due to the higher baking temperature for a shorter time that resulted the cone to be baked sufficiently.

The brittleness of the ice cream wafer cone of sample 2 which the batter was mixed with the water of 20°C baked for 3 minutes, the wafer baked at 180°C has the lowest value of brittleness compared to the ice cream wafer cone that has been baked at 150, 160 and 170°C. Based on Appendix 2, the value of brittleness for the ice cream wafer cone baked at 180°C for 3 minutes was 0.40 mm while the value of brittleness for the ice cream wafer cone at 150, 160 and 170°C were 0.71, 0.57 and 0.42 mm respectively. This can be seen that the ice cream wafer cone that has been baked at 180°C was not brittle as much as the ice cream wafer cone baked at 150 and 160°C. This was due to the different amount of heat received by the ice cream wafer cone during baking where the ice cream wafer cone bake at 170 and 180°C were baked at a higher temperature for a shorter time that resulted ice cream wafer cone baked sufficiently.

The brittleness of the ice cream wafer cone of sample 3 which the batter was mixed with the water of 26°C baked for 3 minutes, the wafer baked at 170°C has the lowest value of brittleness compared to the ice cream wafer cone that has been baked at 150, 160 and 180°C. Based on Appendix 2, the value of brittleness for the ice cream wafer cone baked at 170°C for 3 minutes was 0.56 mm while the value of brittleness for the ice cream wafer cone at 150, 160 and 180°C were 1.00, 1.33 and 0.77 mm respectively. This can be seen that the ice cream wafer cone that has been baked at 170°C was not brittle as much as the ice cream wafer cone baked at 150 and 160°C. This is due to the different amount of heat received by the ice cream wafer cone during baking where the ice cream wafer cone bake at 170°C was baked at a higher temperature that can result the overbake ice cream wafer cone. Supposedly, the ice cream wafer cone bake at 180°C should have the lowest value of brittleness because it was bake at higher baking temperature. However, the value of brittleness of the ice cream wafer cone baked at 180°C was quite higher due to the ice cream wafer cone 's moulding was not fully heated up to 180°C.

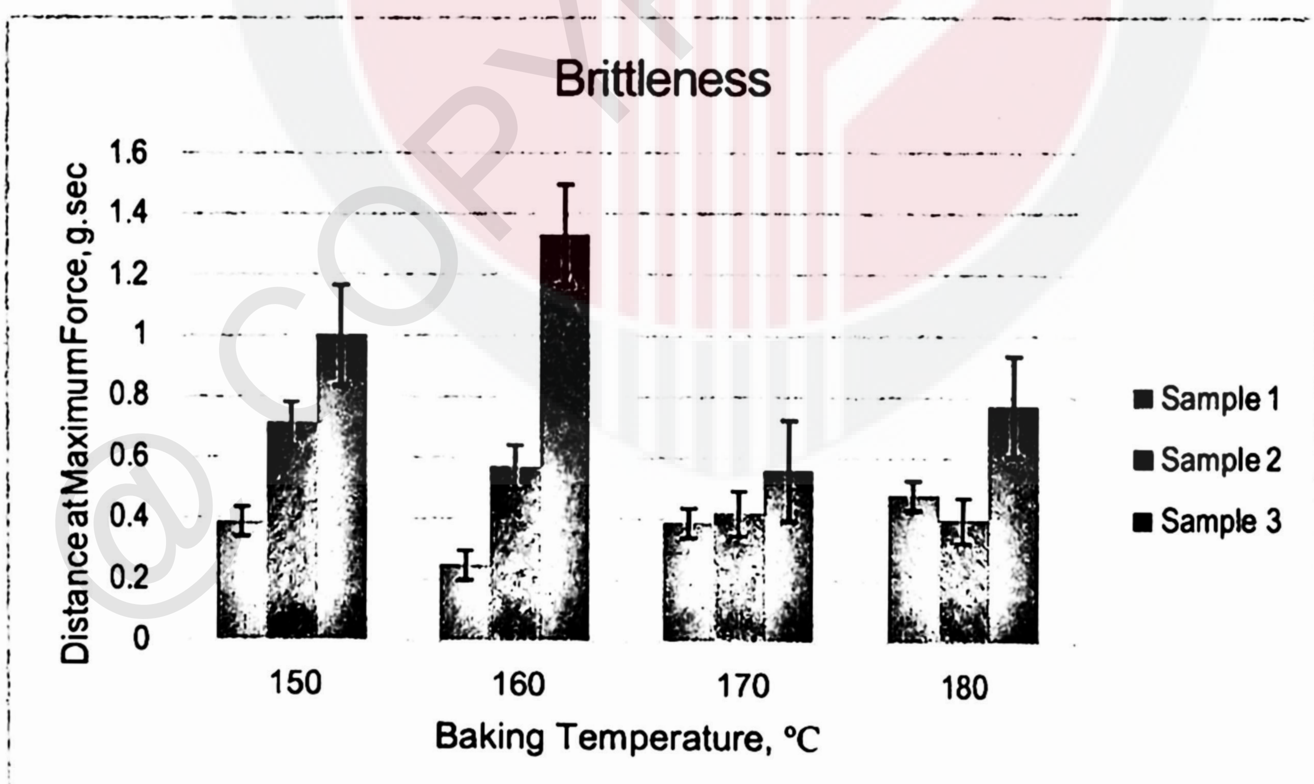

Figure 4.4: Graph of the brittleness of ice cream wafer cone at different baking temperature and baking time for 3 minutes

Based on Figure 4.5, the brittleness of the ice cream wafer cone of sample 1 which the batter was mixed with the water of 14°C baked for 4 minutes, the wafer baked at 160°C has the lowest value of brittleness compared to the ice cream wafer cone that has been baked at 150, 170 and 180°C. Based on Appendix 2, the value of brittleness for the ice cream wafer cone baked at 160°C for 4 minutes was 0.35 mm while the value of brittleness for the ice cream wafer cone at 150, 170 and 180°C were 0.42, 0.45 and 0.36 mm respectively. This can be seen that the ice cream wafer cone that has been baked at 160 and 180°C was not brittle as much as the ice cream wafer cone baked at 150 and 170°C. This was due to the different amount of heat received by the ice cream wafer cone during baking. As for the ice cream wafer cone that has been baked at 150 and 170°C, the ice cream wafer cone was brittle because the ice cream wafer cone fully baked due to the shorter time of baking at lower and high temperature while the ice cream wafer cone baked at 180°C were not brittle due to the higher baking temperature that may cause the ice cream wafer cone to be overbaked.

The brittleness of the ice cream wafer cone of sample 2 which the batter was mixed with the water of 20°C baked for 4 minutes, the wafer baked at 180°C has the lowest value of brittleness compared to the ice cream wafer cone that has been baked at 150, 160 and 170°C. Based on Appendix 2, the value of brittleness for the ice cream wafer cone baked at 180°C for 4 minutes was 0.35 mm while the value of brittleness for the ice cream wafer cone at 150, 160 and 170°C were 0.84, 0.72 and 0.55 mm respectively. This can be seen that the ice cream wafer cone that has been baked at 170 and 180°C was not brittle as much as the ice cream wafer cone baked at 150 and 160°C. This was due to the different amount of heat received by the ice cream wafer cone during baking. As for the ice cream wafer cone that has been baked at 150 and 160°C, the ice cream wafer cone was brittle because the ice cream wafer cone was fully baked due to the suitable time of baking at desired temperature. As for the wafer baked at 170 and

180°C, the ice cream wafer cone was not brittle due to the higher baking temperature during baking process which resulted the ice cream wafer cone tends to be burnt and become hard.

The brittleness of the ice cream wafer cone of sample 3 which the batter was mixed with the water of 26°C baked for 4 minutes, the wafer baked at 160°C has the lowest value of brittleness compared to the ice cream wafer cone that has been baked at 150, 170 and 180°C. Based on Appendix 2, the value of brittleness for the ice cream wafer cone baked at 160°C for 4 minutes was 0.48 mm while the value of brittleness for the ice cream wafer cone at 150, 170 and 180°C were 0.80, 0.72 and 0.70 mm respectively. This can be seen that the ice cream wafer cone that has been baked at 160°C was not brittle as much as the ice cream wafer cone baked at 150, 170 and 180°C. This was due to the different amount of heat received by the ice cream wafer cone during baking where the ice cream wafer cone's moulding was not fully heated up 160°C that resulted the ice cream wafer cone not fully baked.

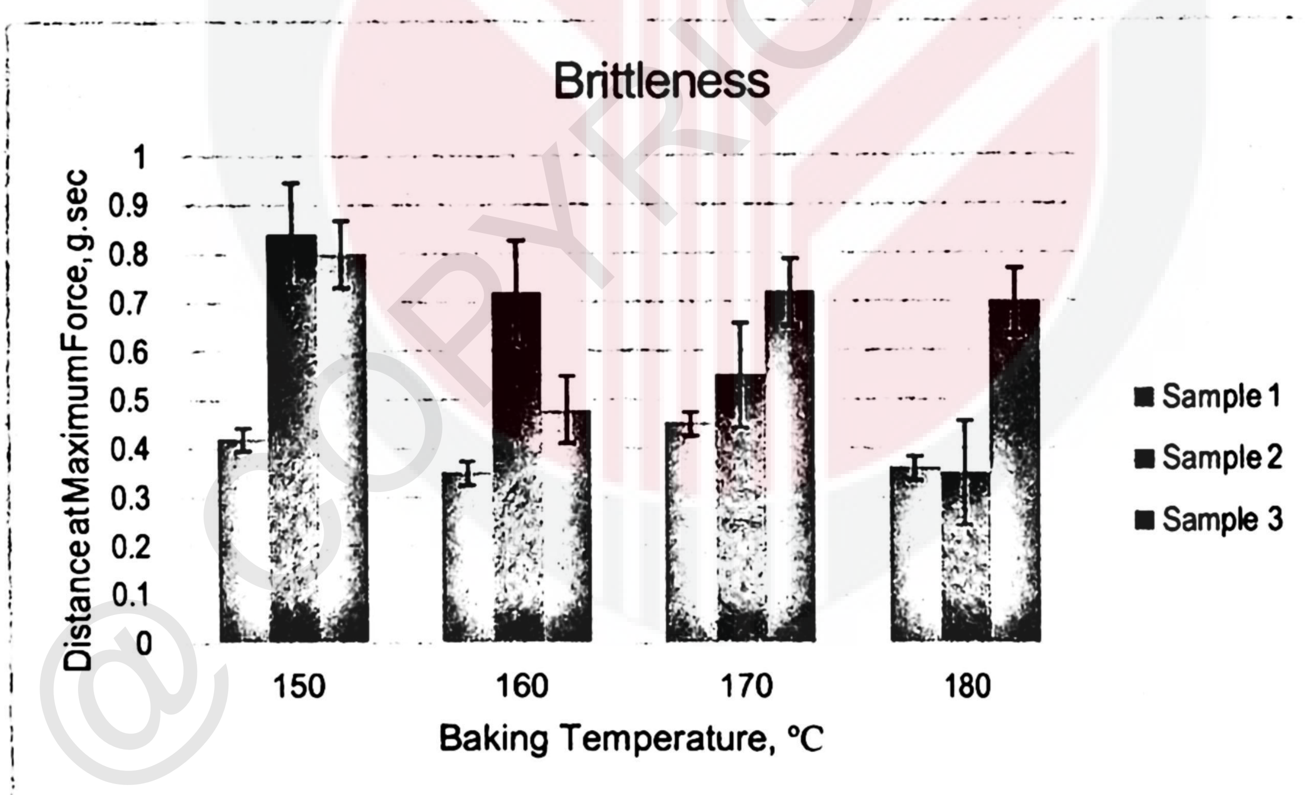

Figure 4.5: Graph of the brittleness of ice cream wafer cone at different baking temperature and baking time for 4 minutes

Based on Figure 4.6, the brittleness of the ice cream wafer cone of sample 1 which the batter was mixed with the water of 14°C baked for 5 minutes, the wafer baked at 150°C has the lowest value of brittleness compared to the ice cream wafer cone that has been baked at 160, 170 and 180°C. Based on Appendix 2, the value of brittleness for the ice cream wafer cone baked at 150°C for 5 minutes was 0.25 mm while the value of brittleness for the ice cream wafer cone at 160, 170 and 180°C were 0.48, 0.37 and 0.39 mm respectively. This can be seen that the ice cream wafer cone that has been baked at 150°C was not brittle as much as the ice cream wafer cone baked at 150, 170 and 180°C. This was due to the different amount of heat received by the ice cream wafer cone during baking where the ice cream wafer cone's moulding was not fully heated up to 150°C. As for the ice cream wafer cone that has been baked at 160°C, the ice cream wafer cone was brittle because the ice cream wafer cone was baked perfectly compared to the ice cream wafer cone bake at 170 and 180°C.

The brittleness of the ice cream wafer cone of sample 2 which the batter was mixed with the water of 20°C baked for 5 minutes, the wafer baked at 180°C has the lowest value of brittleness compared to the ice cream wafer cone that has been baked at 150, 160 and 170°C. Based on Appendix 2, the value of brittleness for the ice cream wafer cone baked at 150°C for 5 minutes was 0.34 mm while the value of brittleness for the ice cream wafer cone at 150, 160 and 170°C were 1.12, 0.47 and 0.41 mm respectively. This can be seen that the ice cream wafer cone that has been baked at 160, 170and 180°C was not brittle as much as the ice cream wafer cone baked at 150°C. This was due to the different amount of heat received by the ice cream wafer cone during baking. As for the ice cream wafer cone that has been baked at 150°C, the ice cream wafer cone was brittle because the ice cream wafer cone was fully baked due to the suitable time of baking at desired temperature while the ice cream wafer cone baked at 170, 160 and 180°C, the ice cream wafer cone was not brittle as much as ice cream wafer cone baked at 150°C due to the higher temperature of baking for a longer time that can cause the ice cream wafer cone to be overbaked.

The of the ice cream wafer cone of sample 3 which the batter was mixed with the water of 26°C baked for 5 minutes, the wafer baked at 160°C has the lowest value of brittleness compared to the ice cream wafer cone that has been baked at 150, 170 and 180°C. Based on Appendix 2, the value of brittleness for the ice cream wafer cone baked at 160°C for 4 minutes was 0.57 mm while the value of brittleness for the ice cream wafer cone at 150, 170 and 180°C were 0.69, 0.96 and 1.01 mm respectively. This can be seen that the ice cream wafer cone that has been baked at 160°C was not brittle as much as the ice cream wafer cone baked at 150, 170 and 180°C. This was due to the different amount of heat received by the ice cream wafer cone during baking where the ice cream wafer cone's moulding was not fully heated up 160°C that resulted the ice cream wafer cone not fully baked.

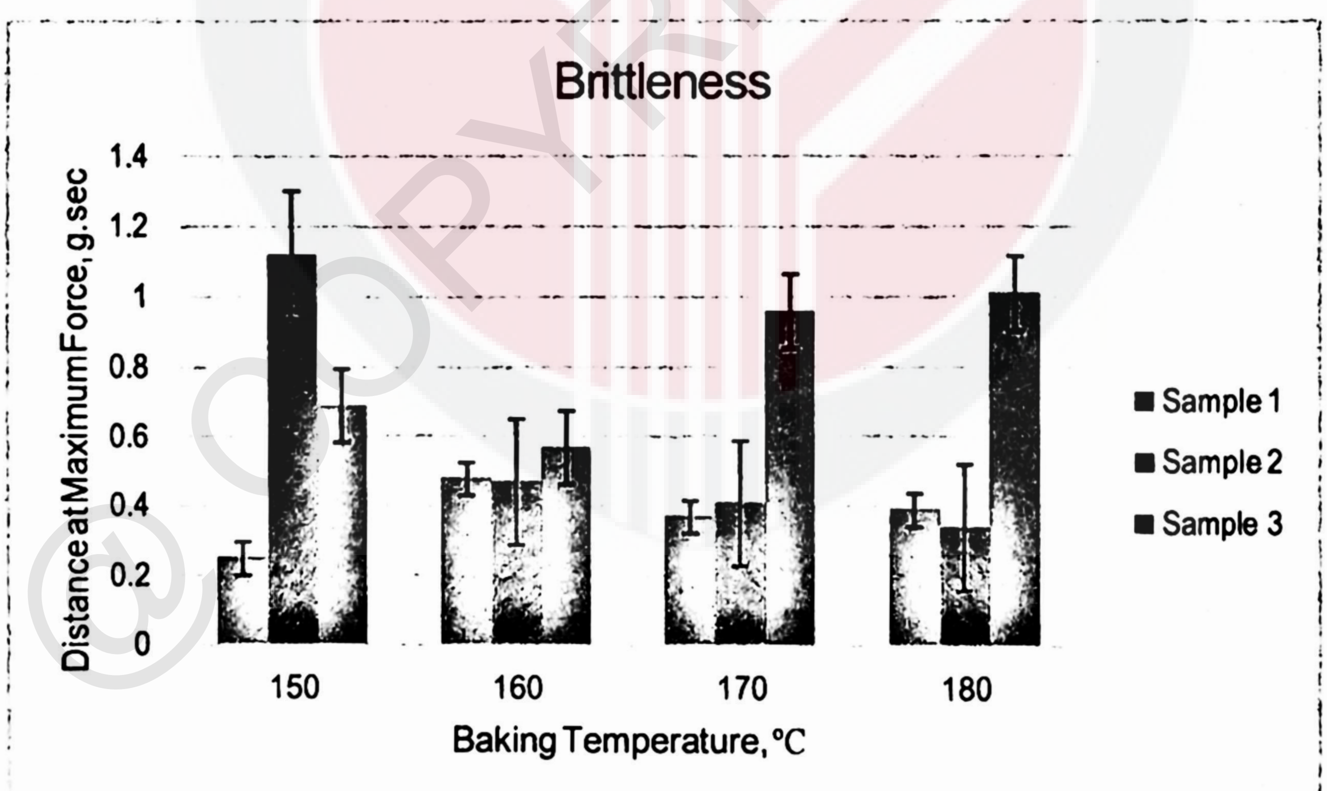

Figure 4.6: Graph of the brittleness of ice cream wafer cone at different baking temperature and baking time for 5 minutes

4.3.2.1 Comparison between the samples and commercial ice cream wafer cone on brittleness

Comparing the result of the brittleness of the ice cream wafer cone for Sample 1 which has used the temperature of water at 14°C and the brittleness of commercial ice cream wafer cone, it can be concluded that none of the ice cream wafer cone bake at 150, 160, 170 and 180°C for 3, 4 and 5 minutes has the value of brittleness which was near to the value of the maximum force needed by the commercial ice cream wafer cone which was 2.42 mm.

Comparing the result of the brittleness of the ice cream wafer cone for Sample 2 which has used the temperature of water at 20°C and the brittleness of commercial ice cream wafer cone, it can be conclude that none of the ice cream wafer cone bake at 150 and 160°C for 4 minutes and the ice cream wafer cone that has been baked at 150°C for 5 minutes has the value of brittleness which were near to the value of the maximum force needed by the commercial ice cream wafer cone which was 2.42 mm.

Comparing the result of the brittleness of the ice cream wafer cone for Sample 3 which has used the temperature of water at 26°C and the brittleness of commercial ice cream wafer cone, it can be conclude that the ice cream wafer cone bake at 150°C for 4 minutes and the ice cream wafer cone that has been baked at 160°C for 3 minutes has the value of brittleness which were near to the value of the maximum force needed by the commercial ice cream wafer cone which was 2.42 mm.

Among the three different types of the Sample that have different temperature of water, Sample 2 has a higher value of brittleness of the ice cream wafer cone compared to Sample 1 and 3. The brittleness of the baked wafer decreases as the hardness increases this was because the ice cream wafer cone that has a hard texture of wafer were not brittle compared to the ice cream wafer cone that has soft texture of ice cream wafer cone. According to Blanshard (1986), the brittle baked product may have starch swollen which called gelatinisation of starch. This explained well why the brittleness decreases when the hardness increases.

Table 4.3: Brittleness of commercial ice cream wafer cone

Commercial ice cream wafer cone	Brittleness, mm Average (±SD)
	2.42 (±0.15)

4.3.3 Effect of baking temperature and time on toughness

Based on Figure 4.7, the toughness of the ice cream wafer cone of sample 1 which the batter was mixed with the water of 14°C baked for 3 minutes, the wafer baked at 150°C has the highest value of toughness compared to the ice cream wafer cone that has been baked at 160, 170 and 180°C. This was due to the amount of heat required for the ice cream wafer cone was not enough to fully bake the ice cream wafer cone. Based on Appendix 3, the value of toughness for the ice cream wafer cone baked at 150°C for 3 minutes was 53.12 g.sec while the value of toughness for the ice cream wafer cone at 160, 170 and 180°C were 36.97, 36.68 and 52.82 g.sec respectively. The value of toughness for the ice cream wafer cone that has been baked at 150°C was higher compared to 160 and 170°C because the ice cream wafer cone was not fully baked since the baking time was not enough for the ice cream wafer cone to be baked at 150°C. Hence, the wafer was not fully baked while the ice cream wafer cone baked at 180°C also higher due to the higher baking temperature that resulted in overbaked ice cream wafer cone.

The toughness of the ice cream wafer cone of sample 2 which the batter was mixed with the water of 20°C baked for at 3 minutes, the wafer baked at 150 and 160°C has the higher value of toughness compared to the ice cream wafer cone that has been baked at 170 and 180°C. This was due to the amount of heat required for the ice cream wafer cone was not enough to fully bake the ice cream wafer cone. Based on Appendix 3, the value of toughness for the ice cream wafer cone baked at 150 and 160°C for 3 minutes were 87.77 and 96.79 g.sec respectively while the value of toughness for the ice cream wafer cone at 170 and 180°C were 51.72 and 51.25 g.sec respectively. The value of toughness for the ice cream wafer cone that has been baked at 150°C was higher compared to 160 and 170°C because the ice cream wafer cone was not fully baked since the baking time was not enough for the ice cream wafer cone to be baked at 150°C. Hence, the wafer was not fully baked while the ice cream wafer cone baked at 180°C also higher due to the higher baking temperature that resulted in an overbaked ice cream wafer cone.

The toughness of the ice cream wafer cone of sample 3 which the batter was mixed with the water of 26°C baked for 3 minutes, the wafer baked at 150°C has the highest value of toughness compared to the ice cream wafer cone that has been baked at 160, 170 and 180°C. This was due to the amount of heat required for the ice cream wafer cone was not enough to fully bake the ice cream wafer cone. Based on Appendix 3, the value of toughness for the ice cream wafer cone baked at 150°C for 3 minutes was 144.71 g.sec while the value of toughness for the ice cream wafer cone at 160, 170 and 180°C were 104.62, 82.75 and 141.55 g.sec respectively. The value of toughness for the ice cream wafer cone that has been baked at 150°C was higher compared to 160, 170 and 180°C because the ice cream wafer cone was not fully baked since the baking time was not enough for the ice cream wafer cone to be baked at 150°C. Hence, the ice cream wafer cone obtained was not fully baked.

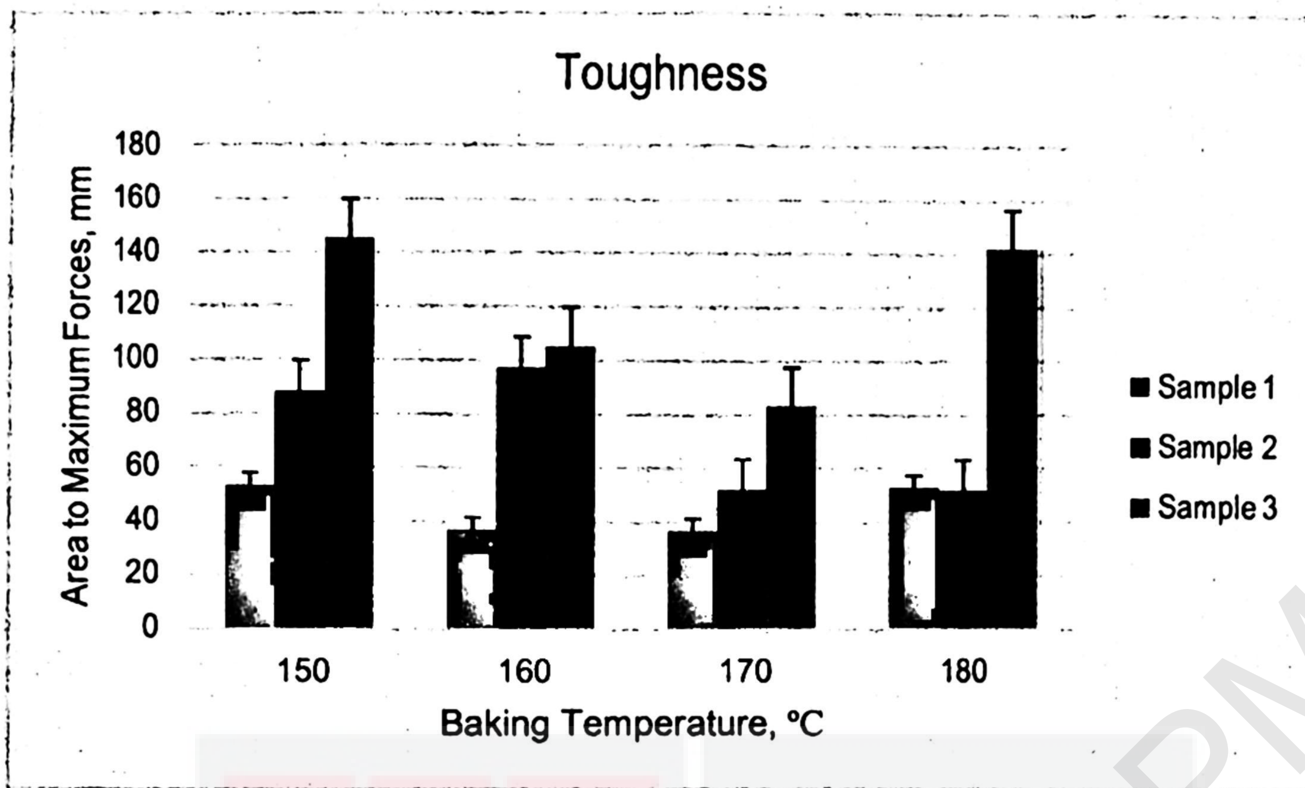

Figure 4.7: Graph of the toughness of ice cream wafer cone at different baking temperature and baking time for 3 minutes

Based on Figure 4.8, the toughness of the ice cream wafer cone of sample 1 which the batter was mixed with the water of 14°C baked for 4 minutes, the wafer baked at 150°C has the highest value of toughness compared to the ice cream wafer cone that has been baked at 160, 170 and 180°C. This was due to the amount of heat required for the ice cream wafer cone was not enough to fully bake the ice cream wafer cone. Based on Appendix 3, the value of toughness for the ice cream wafer cone baked at 150°C for 4 minutes was 63.40 g.sec while the value of toughness for the ice cream wafer cone at 160, 170 and 180°C were 51.20, 51.89 and 45.45 g.sec respectively. The value of toughness for the ice cream wafer cone that has been baked at 150°C was higher compared to 160 and 170°C because the ice cream wafer cone was not fully baked since the baking time was not enough for the ice cream wafer cone to be baked at 150°C. Hence, the wafer was not fully baked.

The toughness of the ice cream wafer cone of sample 2 which the batter was mixed with the water of 20°C baked for 4 minutes, the wafer baked at 150°C has the highest value of toughness compared to the ice cream wafer cone that has been baked at 160, 170 and 180°C.

This was due to the amount of heat required for the ice cream wafer cone was enough to fully bake the ice cream wafer cone. Based on Appendix 3, the value of toughness for the ice cream wafer cone baked at 150°C for 4 minutes was 139.34 g.sec while the value of toughness for the ice cream wafer cone at 160, 170 and 180°C were 73.12, 59.16 and 55.19 g.sec respectively. The value of toughness for the ice cream wafer cone that has been baked at 150°C was higher compared to 160, 170 and 180°C because the ice cream wafer cone was fully baked since the baking time was enough for the ice cream wafer cone to be baked at 150°C.

The toughness of the ice cream wafer cone of sample 3 which the batter was mixed with the water of 26°C baked for 4 minutes, the wafer baked at 180°C has the highest value of toughness compared to the ice cream wafer cone that has been baked at 150, 170 and 180°C. This was due to the amount of heat required for the ice cream wafer cone exceed to fully bake the ice cream wafer cone. Based on Appendix 3, the value of toughness for the ice cream wafer cone baked at 180°C for 4 minutes was 153.43 g.sec while the value of toughness for the ice cream wafer cone at 150, 160 and 170°C were 113.31, 66.16 and 87.00 g.sec respectively. The value of toughness for the ice cream wafer cone that has been baked at 180°C was higher compared to 150, 160 and 170°C because the ice cream wafer cone was bake at a higher temperature for a longer time that causes the ice cream wafer cone to be overbaked.

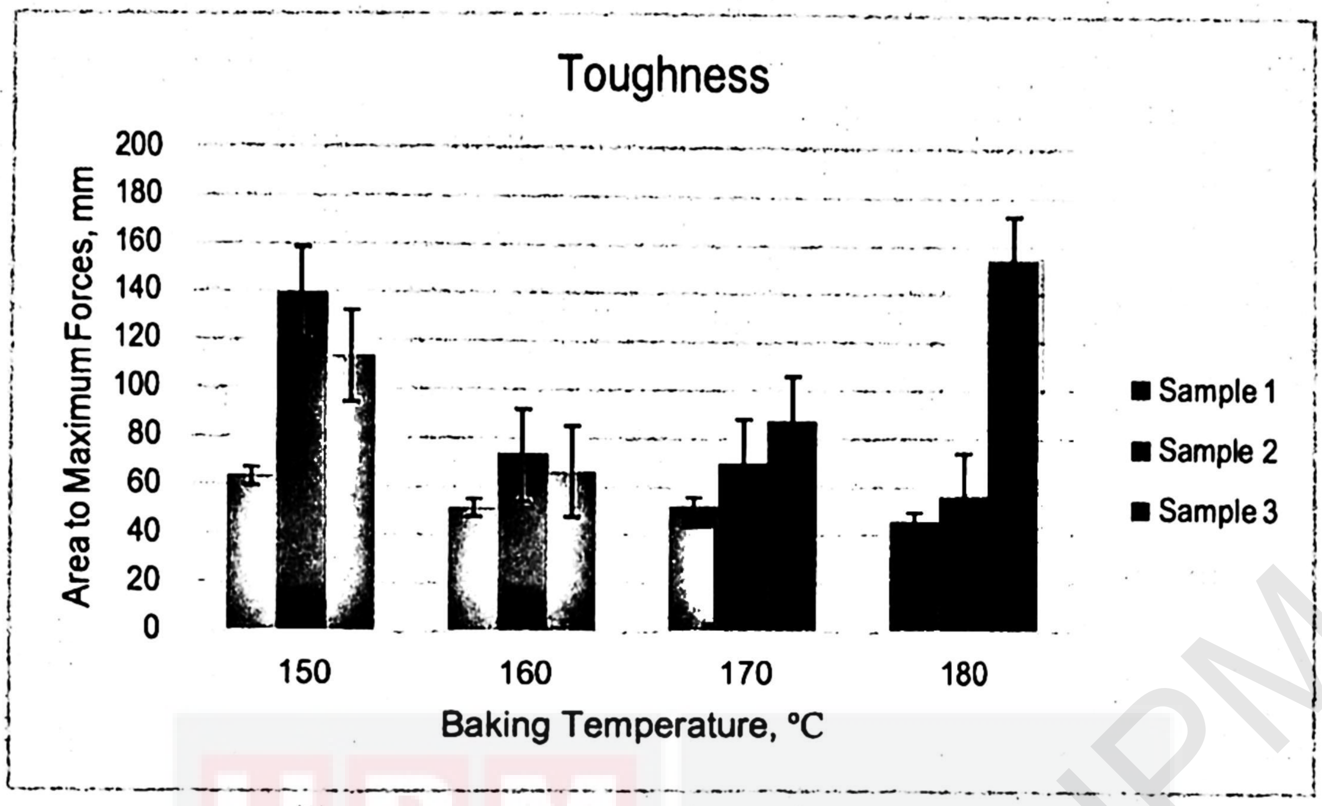

Figure 4.8: Graph of the toughness of ice cream wafer cone at different baking temperature and baking time for 4 minutes

Based on Figure 4.9, the toughness of the ice cream wafer cone of sample 1 which the batter was mixed with the water of 14°C baked for 5 minutes, the wafer baked at 160°C has the highest value of toughness compared to the ice cream wafer cone that has been baked at 150, 170 and 180°C. This was due to the amount of heat required for the ice cream wafer cone was exceed to fully bake the ice cream wafer cone. Based on Appendix 3, the value of toughness for the ice cream wafer cone baked at 160°C for 4 minutes was 72.54 g.sec while the value of toughness for the ice cream wafer cone at 150, 170 and 180°C were 31.07, 55.10 and 61.27 g.sec respectively. The value of toughness for the ice cream wafer cone that has been baked at 160°C was higher compared to 170 and 180°C because the ice cream wafer cone baked at 170 and 180°C were not baked exactly at the desired temperature since the ice cream wafer cone's moulding was not heated up to the desired temperature.

The toughness of the ice cream wafer cone of sample 2 which the batter was mixed with the water of 20°C baked for 5 minutes, the wafer baked at 150°C has the highest value of toughness compared to the ice cream wafer cone that has been baked at 160, 170 and 180°C.

This was due to the amount of heat required for the ice cream wafer cone was enough to fully bake the ice cream wafer cone. Based on Appendix 3, the value of toughness for the ice cream wafer cone baked at 150°C for 5 minutes was 110.69 g.sec while the value of toughness for the ice cream wafer cone at 160, 170 and 180°C were 50.24, 57.89 and 64.94 g.sec respectively. The value of toughness for the ice cream wafer cone that has been baked at 150°C was higher compared to 160, 170 and 180°C because the ice cream wafer cone has been bake at the desired conditions.

The toughness of the ice cream wafer cone of sample 3 which the batter was mixed with the water of 26°C baked for 5 minutes, the wafer baked at 170 and 180°C has the higher value of toughness compared to the ice cream wafer cone that has been baked at 150 and 160°C. This was due to the amount of heat required for the ice cream wafer cone exceed to fully bake the ice cream wafer cone. Based on Appendix 3, the value of toughness for the ice cream wafer cone baked at 170 and 180°C for 5 minutes were 187.70 and 149.71 g.sec respectively while the value of toughness for the ice cream wafer cone at 150 and 160°C were 99.10 and 114.03 g.sec respectively. The value of toughness for the ice cream wafer cone that has been baked at 170 and 180°C was higher compared to 150 and 160°C because the ice cream wafer cone was bake at a higher temperature for a longer time that causes the ice cream wafer cone to be overbaked.

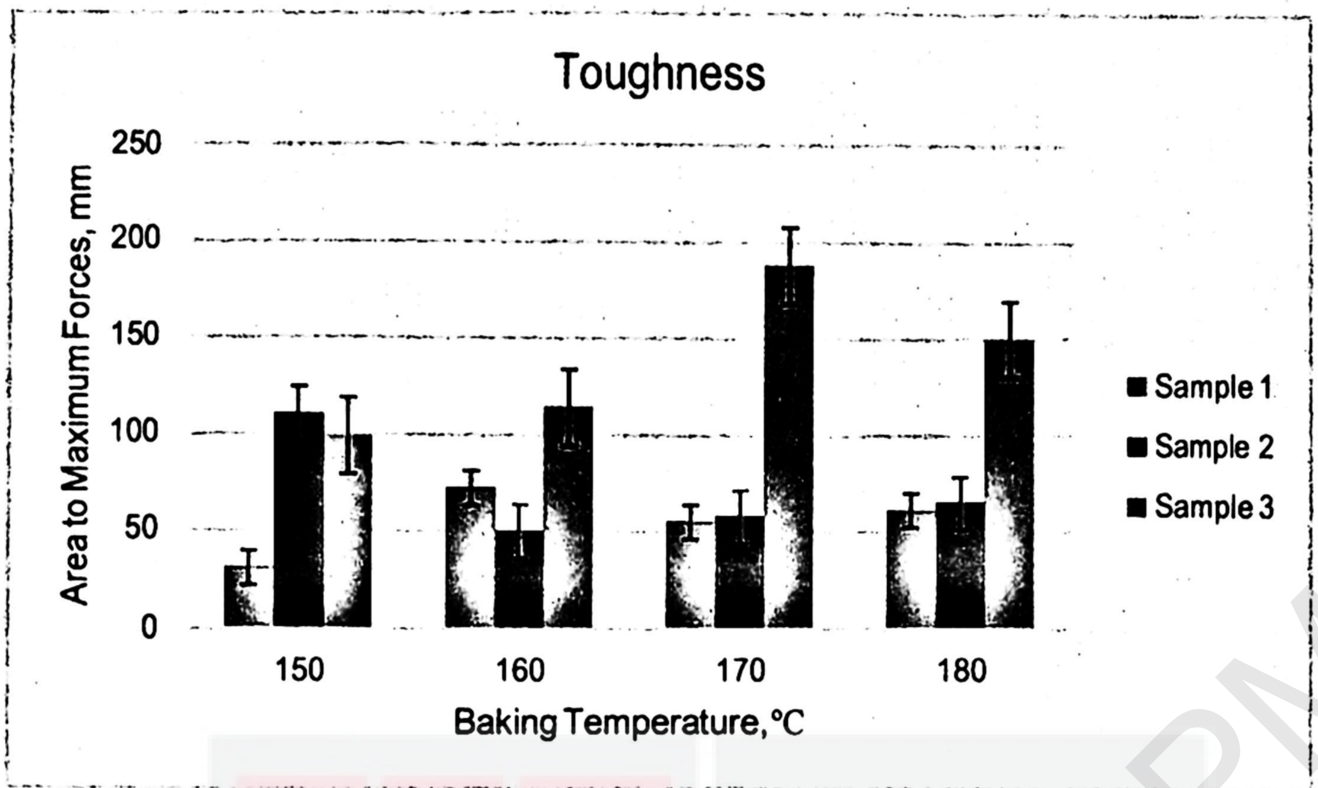

Figure 4.9: Graph of the toughness of ice cream wafer cone at different baking temperature and baking time for 5 minutes

4.3.3.1 Comparison between the samples and commercial ice cream wafer cone on toughness

Comparing the result of toughness of the ice cream wafer cone for Sample 1 which has used the temperature of water at 14°C and the toughness of commercial ice cream wafer cone, it can be conclude that the ice cream wafer cone bake at 160°C for 5 minutes has the value of toughness which was near to the value of the toughness by the commercial ice cream wafer cone which was 200.13 g.sec.

Comparing the result of toughness of the ice cream wafer cone for Sample 2 which has used the temperature of water at 20°C and the toughness of commercial ice cream wafer cone, it can be conclude that the ice cream wafer cone bake at 150°C for 4 and 5 minutes and the ice cream wafer cone bake at 160°C for 3 minutes has the value of toughness which were near to the value of the toughness by the commercial ice cream wafer cone which was 200.13 g.sec.

Comparing the result of toughness of the ice cream wafer cone for Sample 3 which has used the temperature of water at 26°C and the toughness of commercial ice cream wafer cone, it can be conclude that the ice cream wafer cone bake at 150°C for 4 and 5 minutes and the ice cream wafer cone bake at 160°C for 3 and 5 minutes has the value of toughness which were near to the value of the toughness by the commercial ice cream wafer cone which was 200.13 g.sec.

Among the three different types of the Sample that have a different temperature of water, Sample 2 has the medium value of toughness of the ice cream wafer cone which was not too high and not too low compared to Sample 1 and 3. According to Hirahara and Simpson (1961), more gluten development will result in a tougher property of baked foods, however, according to Dogan (2006), the temperature of water alters the viscosity of batter and affects the quality of the sheet. Water temperature should be around 20°C to prevent gluten strand formation. The higher the temperature, the thicker the batter it will be due to the gluten strand formation. That was why the batter with lower temperature result in a low value of toughness property.

Table 4.4: Toughness of commercial ice cream wafer cone

	Toughness, g.sec Average (±SD)
Commercial ice cream wafer cone	200.13 (±58.88)

4.3.4 Effect of baking temperature and time on crispiness

Based on Figure 4.10, the crispiness of the ice cream wafer cone of sample 1 which the batter was mixed with the water of 14°C baked for 3 minutes, the wafer baked at 160°C has the higher value of crispiness compared to the ice cream wafer cone that has been baked at 150, 170 and 180°C. This was due to the amount of heat required for the ice cream wafer cone desirable to fully bake the ice cream wafer cone. Based on Appendix 4, the value of crispiness for the ice cream wafer cone baked at 160°C for 3 minutes was 7.75 while the value of crispiness for the ice cream wafer cone at 150, 160 and 170°C were 6.00, 4.33 and 3.33 respectively. The value of crispiness for the ice cream wafer cone that has been baked at 180°C was lower compared to 150, 160 and 170°C because the ice cream wafer cone was bake at a higher temperature for a longer time that causes the ice cream wafer cone to be overbaked.

The crispiness of the ice cream wafer cone of sample 2 which the batter was mixed with the water of 20°C baked for 3 minutes, the wafer baked at 160°C has the higher value of crispiness compared to the ice cream wafer cone that has been baked at 150, 170 and 180°C. This was due to the amount of heat required for the ice cream wafer cone desirable to fully bake the ice cream wafer cone. Based on Appendix 4, the value of crispiness for the ice cream wafer cone baked at 160°C for 3 minutes was 10.00 while the value of crispiness for the ice cream wafer cone at 150, 160 and 170°C were 7.33, 7.33 and 5.33 respectively. The value of crispiness for the ice cream wafer cone that has been baked at 180°C was lower compared to 150, 160 and 170°C because the ice cream wafer cone was bake at a higher temperature for a longer time that causes the ice cream wafer cone to be overbaked.

The crispiness of the ice cream wafer cone of sample 3 which the batter was mixed with the water of 26°C baked for 3 minutes, the wafer baked at 150°C has the higher value of crispiness compared to the ice cream wafer cone that has been baked at 160, 170 and 180°C. This was due to the amount of heat required for the ice cream wafer cone desirable to fully bake the ice cream wafer cone. Based on Appendix 4, the value of crispiness for the ice cream wafer cone baked at 160°C for 3 minutes was 14.33 while the value of crispiness for the ice cream wafer cone at 160, 170 and 180°C were 7.00, 5.67 and 11.67 respectively. The value of crispiness for the ice cream wafer cone that has been baked at 170°C was high compared to 150, 160 and 180°C because the ice cream wafer cone was bake at higher temperature for a longer time that cause the ice cream wafer cone to be overbaked while value of crispiness for the ice cream wafer cone that has been baked at 180°C was higher compared to 160 and 170°C because the ice cream wafer cone was bake when the ice cream wafer cone's moulding was not heated up to desirable temperature which was 180°C.

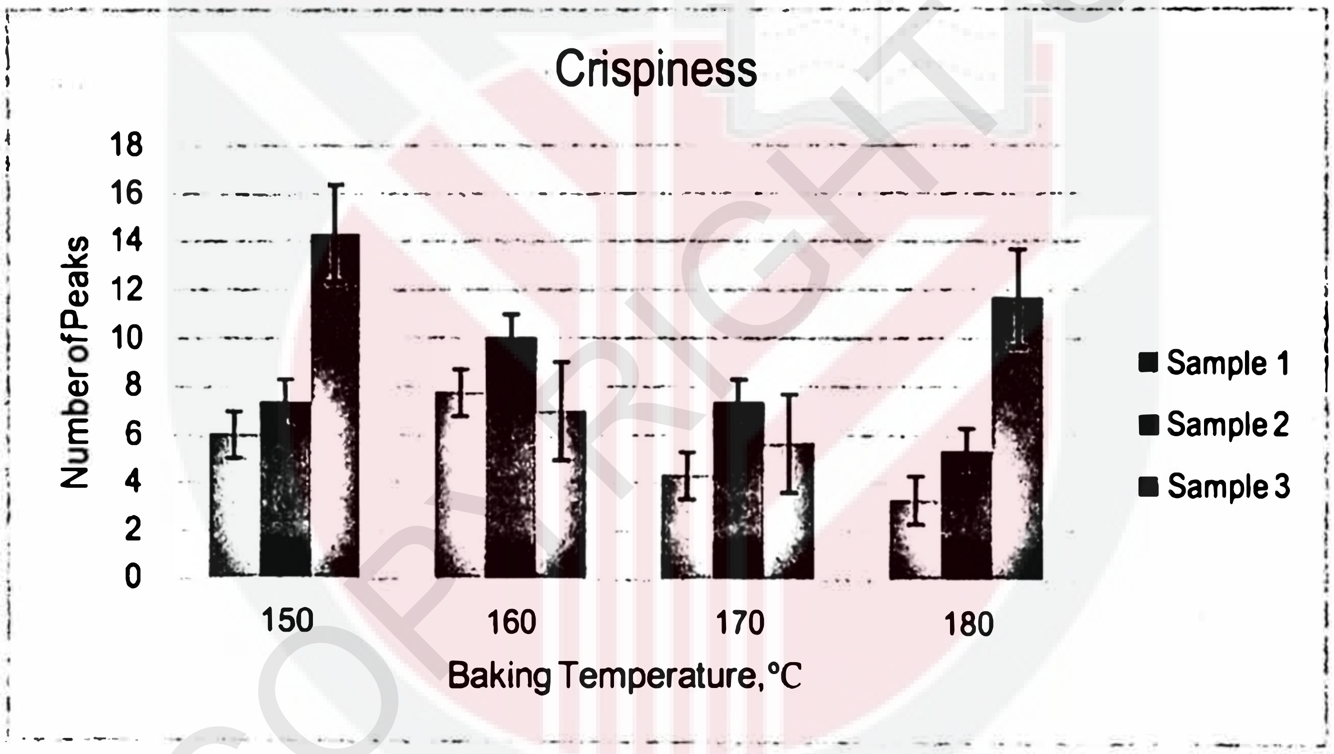

Figure 4.10: Graph of the crispiness of ice cream wafer cone at different baking temperature and baking time for 3 minutes

Based on Figure 4.11, the crispiness of the ice cream wafer cone of sample 1 which the batter was mixed with the water of 14°C baked for 4 minutes, the wafer baked at 150°C has the higher value of crispiness compared to the ice cream wafer cone that has been baked at 160, 170 and 180°C. This was due to the amount of heat required for the ice cream wafer cone desirable to fully bake the ice cream wafer cone. Based on Appendix 4, the value of crispiness for the ice cream wafer cone baked at 150°C for 4 minutes was 8.20 while the value of crispiness for the ice cream wafer cone at 160, 170 and 180°C were 5.00, 2.67 and 7.67 respectively. The value of crispiness for the ice cream wafer cone that has been baked at 180°C was higher compared to 160 and 170°C because the ice cream wafer cone was bake when the ice cream wafer cone's moulding was not heated up to desirable temperature which was 180°C. That was why the crispiness of ice cream wafer cone baked at 180°C was quite higher compared to the ice cream wafer cone baked at 160 and 170°C which were almost overbaked.

The crispiness of the ice cream wafer cone of sample 2 which the batter was mixed with the water of 20°C baked for 4 minutes, the wafer baked at 150°C has the higher value of crispiness compared to the ice cream wafer cone that has been baked at 160, 170 and 180°C. This was due to the amount of heat required for the ice cream wafer cone desirable to fully bake the ice cream wafer cone. Based on Appendix 4, the value of crispiness for the ice cream wafer cone baked at 150°C for 4 minutes was 14.67 while the value of crispiness for the ice cream wafer cone at 160, 170 and 180°C were 8.67, 7.00 and 10.00 respectively. The value of crispiness for the ice cream wafer cone that has been baked at 180°C was higher compared to 160 and 170°C because the ice cream wafer cone was bake when the ice cream wafer cone's moulding was not heated up to desirable temperature which was 180°C. That was why the crispiness of ice cream wafer cone baked at 180°C was quite higher compared to the ice cream wafer cone baked at 160 and 170°C.

The crispiness of the ice cream wafer cone of sample 3 which the batter was mixed with the water of 26°C baked for 4 minutes, the wafer baked at 150°C has the higher value of crispiness compared to the ice cream wafer cone that has been baked at 160, 170 and 180°C. This was due to the amount of heat required for the ice cream wafer cone desirable to fully bake the ice cream wafer cone. Based on Appendix 4, the value of crispiness for the ice cream wafer cone baked at 150°C for 4 minutes was 18.00 while the value of crispiness for the ice cream wafer cone at 160, 170 and 180°C were 9.33, 9.67 and 12.67 respectively. The value of crispiness for the ice cream wafer cone that has been baked at 180°C was higher compared to 160 and 170°C because the ice cream wafer cone was bake when the ice cream wafer cone's moulding was not heated up to desirable temperature which was 180°C. That was why the crispiness of ice cream wafer cone baked at 180°C was quite higher compared to the ice cream wafer cone baked at 160 and 170°C.

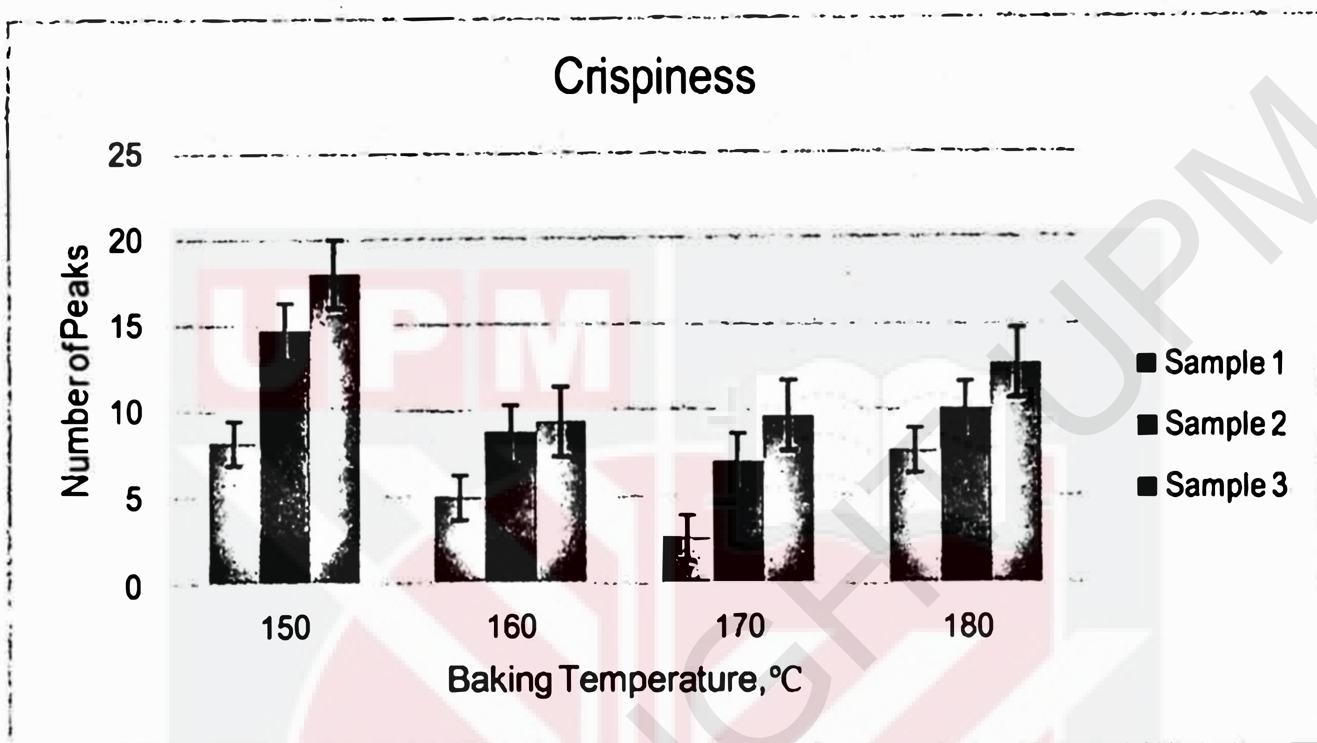

Figure 4.11: Graph of the crispiness of ice cream wafer cone at different baking temperature and baking time for 4 minutes

Based on Figure 4.12, the crispiness of the ice cream wafer cone of sample 1 which the batter was mixed with the water of 14°C baked for 5 minutes, the wafer baked at 180°C has the higher value of crispiness compared to the ice cream wafer cone that has been baked at 150, 160 and 170°C. This was due to the amount of heat required for the ice cream wafer cone desirable to fully bake the ice cream wafer cone. Based on Appendix 4, the value of crispiness for the ice cream wafer cone baked at 180°C for 5 minutes was 7.00 while the value of crispiness for the ice cream wafer cone at 150, 160 and 170°C were 6.00, 3.00 and 3.00 respectively. The value of crispiness for the ice cream wafer cone that has been baked at 180°C was higher compared to 150, 160 and 170°C because the ice cream wafer cone was bake when the ice cream wafer cone's moulding was not heated up to desirable temperature which was

180°C. That was why the crispiness of ice cream wafer cone baked at 180°C was quite higher compared to the ice cream wafer cone baked at 160 and 170°C which were almost overbaked.

The crispiness of the ice cream wafer cone of sample 2 which the batter was mixed with the water of 20°C baked for 5 minutes, the wafer baked at 180°C has the higher value of crispiness compared to the ice cream wafer cone that has been baked at 150, 160 and 170°C. This was due to the amount of heat required for the ice cream wafer cone desirable to fully bake the ice cream wafer cone. Based on Appendix 4, the value of crispiness for the ice cream wafer cone baked at 180°C for 5 minutes was 10.33 while the value of crispiness for the ice cream wafer cone at 150, 160 and 170°C were 10.00, 4.00 and 6.67 respectively. The value of crispiness for the ice cream wafer cone that has been baked at 180°C was higher compared to 150, 160 and 170°C because the ice cream wafer cone was bake when the ice cream wafer cone's moulding was not heated up to desirable temperature which was 180°C. That was why the crispiness of ice cream wafer cone baked at 180°C was quite higher compared to the ice cream wafer cone baked at 160 and 170°C which were almost overbaked.

The crispiness of the ice cream wafer cone of sample 3 which the batter was mixed with the water of 26°C baked for 5 minutes, the wafer baked at 180°C has the higher value of crispiness compared to the ice cream wafer cone that has been baked at 150, 160 and 170°C. This was due to the amount of heat required for the ice cream wafer cone desirable to fully bake the ice cream wafer cone. Based on Appendix 4, the value of crispiness for the ice cream wafer cone baked at 180°C for 5 minutes was 44.67 while the value of crispiness for the ice cream wafer cone at 150, 160 and 170°C were 10.00, 4.00 and 6.67 respectively. The value of crispiness for the ice cream wafer cone that has been baked at 180°C was higher compared to 150, 160 and 170°C because the ice cream wafer cone was bake when the ice cream wafer cone's moulding was not heated up to desirable temperature which was 180°C. That was why the crispiness of ice cream wafer cone baked at 180°C was quite higher compared to the ice cream wafer cone baked at 160 and 170°C which were almost overbaked.

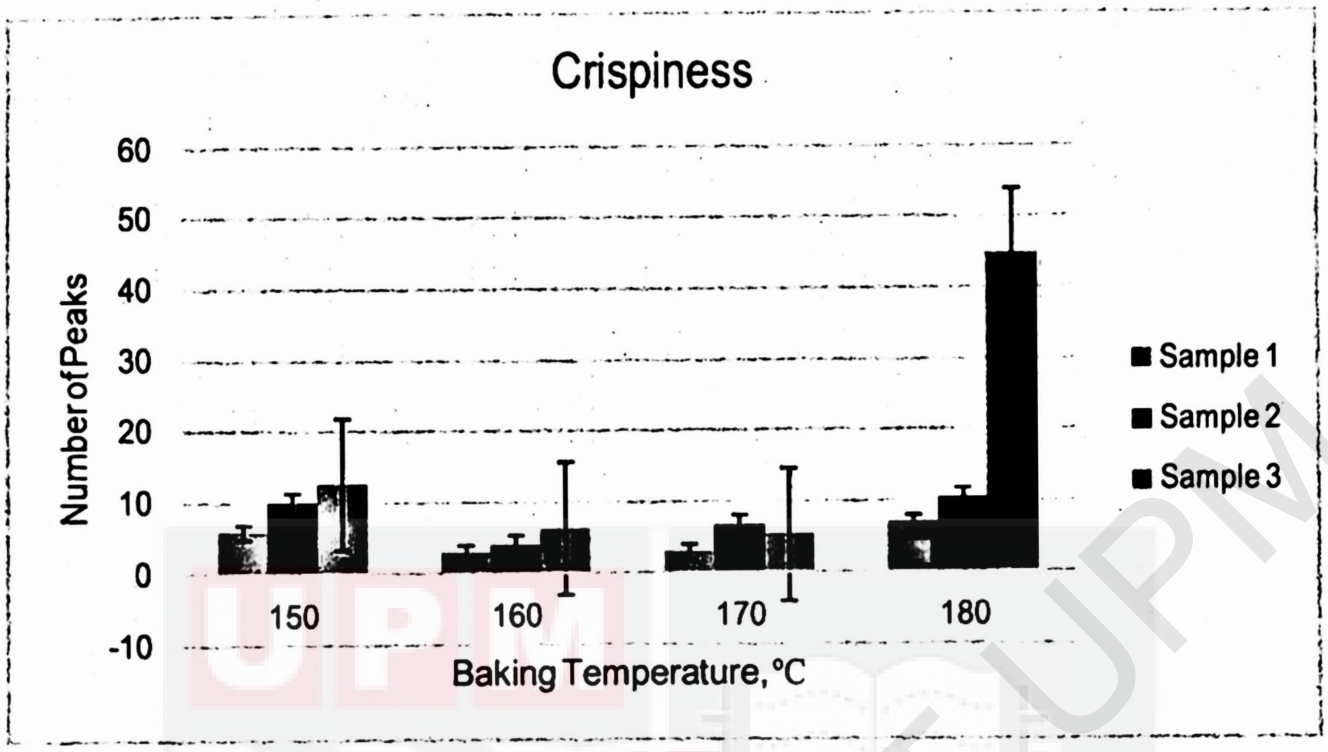

Figure 4.12: Graph of the crispiness of ice cream wafer cone at different baking temperature and baking time for 5 minutes

4.3.4.1 Comparison between the samples and commercial ice cream wafer cone on crispiness

Comparing the result of crispiness of the ice cream wafer cone for Sample 1 which has used the temperature of water at 14°C and the crispiness of commercial ice cream wafer cone, it can be conclude that the ice cream wafer cone bake at 150 and 180°C for 4 minutes and the ice cream wafer cone bake at 160°C for 3 minutes has the value of crispiness which were near to the value of the crispiness by the commercial ice cream wafer cone which was 18.56.

Comparing the result of crispiness of the ice cream wafer cone for Sample 2 which has used the temperature of water at 20°C and the crispiness of commercial ice cream wafer cone, it can be conclude that the ice cream wafer cone bake at 150°C for 4 and 5 minutes and the ice cream wafer cone bake at 160°C for 3 and 4 minutes has the value of crispiness which were near to the value of the crispiness by the commercial ice cream wafer cone which was 18.56.

Comparing the result of crispiness of the ice cream wafer cone for Sample 3 which has used the temperature of water at 26°C and the crispiness of commercial ice cream wafer cone, it can be conclude that the ice cream wafer cone bake at 150°C for 4 and 5 minutes and the ice cream wafer cone bake at 160 and 170°C for 4 minutes has the value of crispiness which were near to the value of the crispiness by the commercial ice cream wafer cone which was 18.56.

Among the three different types of the Sample that have a different temperature of water, Sample 2 has the higher value of crispiness of the ice cream wafer cone which was not too high and not too low compared to Sample 1 and 3. According to Cauvain and Young with increasing water activity, the wafer texture changes from a soft to a harder crispness, accompanied by higher mechanical stability, which was good both for handling and for the final product texture. That was why the ice cream wafer cone bake at a lower temperature will have a higher value of crispiness compared to the ice cream wafer cone baked at higher temperature due to the moisture content of the ice cream wafer cone.

Table 4.5: Crispiness of commercial ice cream wafer cone

	Crispiness Average (±SD)
Commercial ice cream wafer cone	18.56 (±0.51)

4.4 Effect of baking temperature and time on moisture content

According to Cauvain and Young, in order to compensate for low water activity, humidity conditioning up to 4.5% wafer moisture was possible. Moreover, with increasing water activity, the wafer texture changes from a soft to a harder crispness, accompanied by higher mechanical stability, which was good both for handling and for the final product texture. Up to 5-6% moisture content, the wafer sheets keep their typical crisp texture, but higher moisture levels will result in most cases was inadequate, tough, or even soft and soggy textures.

Based on Figure 4.13, the moisture content of the ice cream wafer cone of sample 1 which the batter was mixed with the water of 14°C baked for 3 minutes, the wafer baked at 150°C has the higher value of moisture content compared to the ice cream wafer cone that has been baked at 160, 170 and 180°C. The value of moisture content for the ice cream wafer cone baked at 150°C for 3 minutes was 5.63 while the value of moisture content for the ice cream wafer cone at 160, 170 and 180°C were 3.95, 3.70 and 2.75 respectively. The value of moisture content for the ice cream wafer cone that has been baked at 180°C was lower compared to 150, 160 and 170°C because the ice cream wafer cone was baked at higher temperature compared to the ice cream wafer cone baked at 150, 160 and 170°C.

The moisture content of the ice cream wafer cone of sample 2 which the batter was mixed with the water of 20°C baked for 3 minutes, the wafer baked at 150°C has the higher value of moisture content compared to the ice cream wafer cone that has been baked at 160, 170 and 180°C. The value of moisture content for the ice cream wafer cone baked at 150°C for 3 minutes was 5.51 while the value of moisture content for the ice cream wafer cone at 160, 170 and 180°C were 4.09, 3.23 and 2.91 respectively. The value of moisture content for the ice cream wafer cone that has been baked at 180°C was lower compared to 150, 160 and 170°C because the ice cream wafer cone was baked at higher temperature compared to the ice cream wafer cone baked at 150, 160 and 170°C.

The moisture content of the ice cream wafer cone of sample 3 which the batter was mixed with the water of 26°C baked for 3 minutes, the wafer baked at 150°C has the higher value of moisture content compared to the ice cream wafer cone that has been baked at 160, 170 and 180°C. The value of moisture content for the ice cream wafer cone baked at 150°C for 3 minutes was 5.76 while the value of moisture content for the ice cream wafer cone at 160, 170 and 180°C were 3.45, 3.55 and 2.44 respectively. The value of moisture content for the ice cream wafer cone that has been baked at 180°C was lower compared to 150, 160 and 170°C because the ice cream wafer cone was baked at higher temperature compared to the ice cream wafer cone baked at 150, 160 and 170°C.

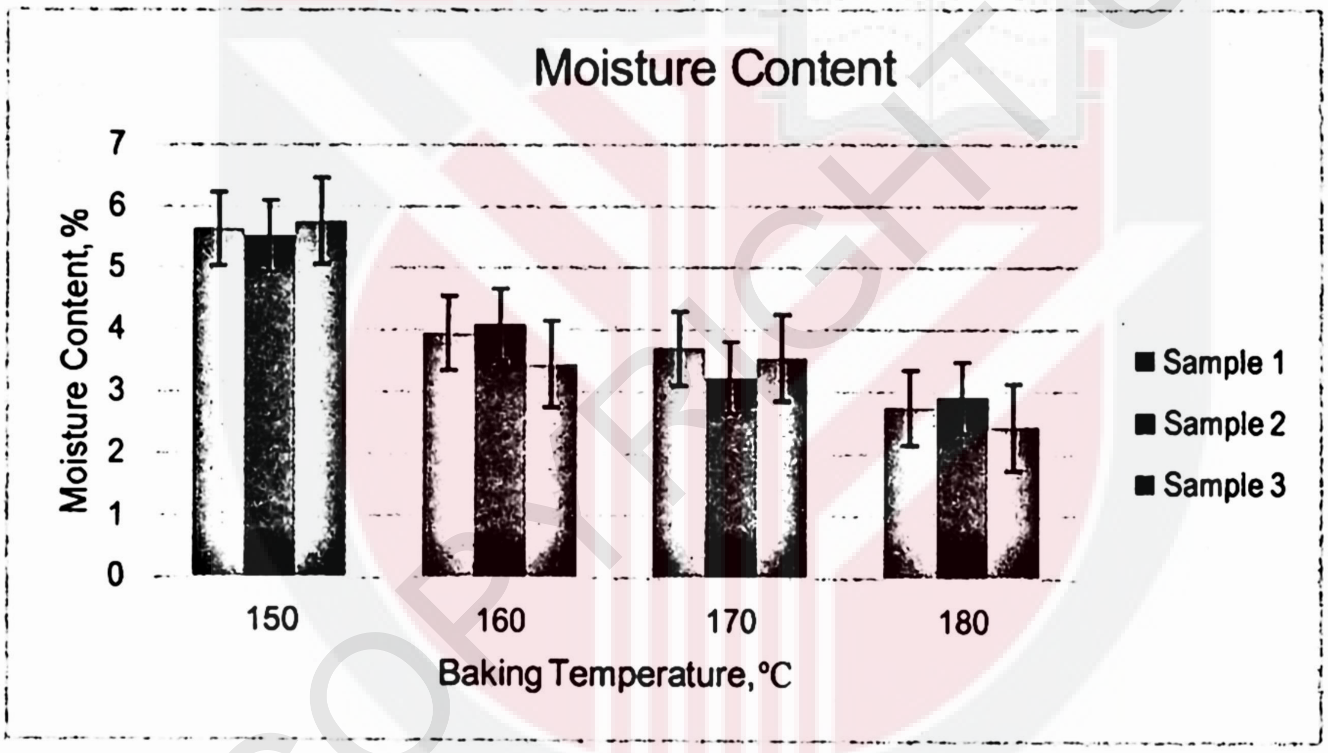

Figure 4.13: Graph of moisture content of ice cream wafer cone at different baking temperature and baking time for 3 minutes

Based on Figure 4.14, the moisture content of the ice cream wafer cone of sample 1 which the batter was mixed with the water of 14°C baked for 4 minutes, the wafer baked at 150°C has the higher value of moisture content compared to the ice cream wafer cone that has been baked at 160, 170 and 180°C. The value of moisture content for the ice cream wafer cone baked at 150°C for 4 minutes was 3.97 while the value of moisture content for the ice cream wafer cone at 160, 170 and 180°C were 2.56, 2.14 and 1.98 respectively. The value of moisture content for the ice cream wafer cone that has been baked at 180°C was lower compared to 150, 160 and 170°C because the ice cream wafer cone was baked at higher temperature compared to the ice cream wafer cone baked at 150, 160 and 170°C.

The moisture content of the ice cream wafer cone of sample 2 which the batter was mixed with the water of 20°C baked for 4 minutes, the wafer baked at 150°C has the higher value of moisture content compared to the ice cream wafer cone that has been baked at 160, 170 and 180°C. The value of moisture content for the ice cream wafer cone baked at 150°C for 4 minutes was 4.05 while the value of moisture content for the ice cream wafer cone at 160, 170 and 180°C were 2.71, 2.47 and 1.92 respectively. The value of moisture content for the ice cream wafer cone that has been baked at 180°C was lower compared to 150, 160 and 170°C because the ice cream wafer cone was baked at higher temperature compared to the ice cream wafer cone baked at 150, 160 and 170°C.

The moisture content of the ice cream wafer cone of sample 3 which the batter was mixed with the water of 26°C baked for 4 minutes, the wafer baked at 150°C has the higher value of moisture content compared to the ice cream wafer cone that has been baked at 160, 170 and 180°C. The value of moisture content for the ice cream wafer cone baked at 150°C for 4 minutes was 5.76 while the value of moisture content for the ice cream wafer cone at 160, 170 and 180°C were 3.45, 3.55 and 2.44 respectively. The value of moisture content for the ice cream wafer cone that has been baked at 180°C was lower compared to 150, 160 and 170°C because the ice cream wafer cone was baked at higher temperature compared to the ice cream wafer cone baked at 150, 160 and 170°C.

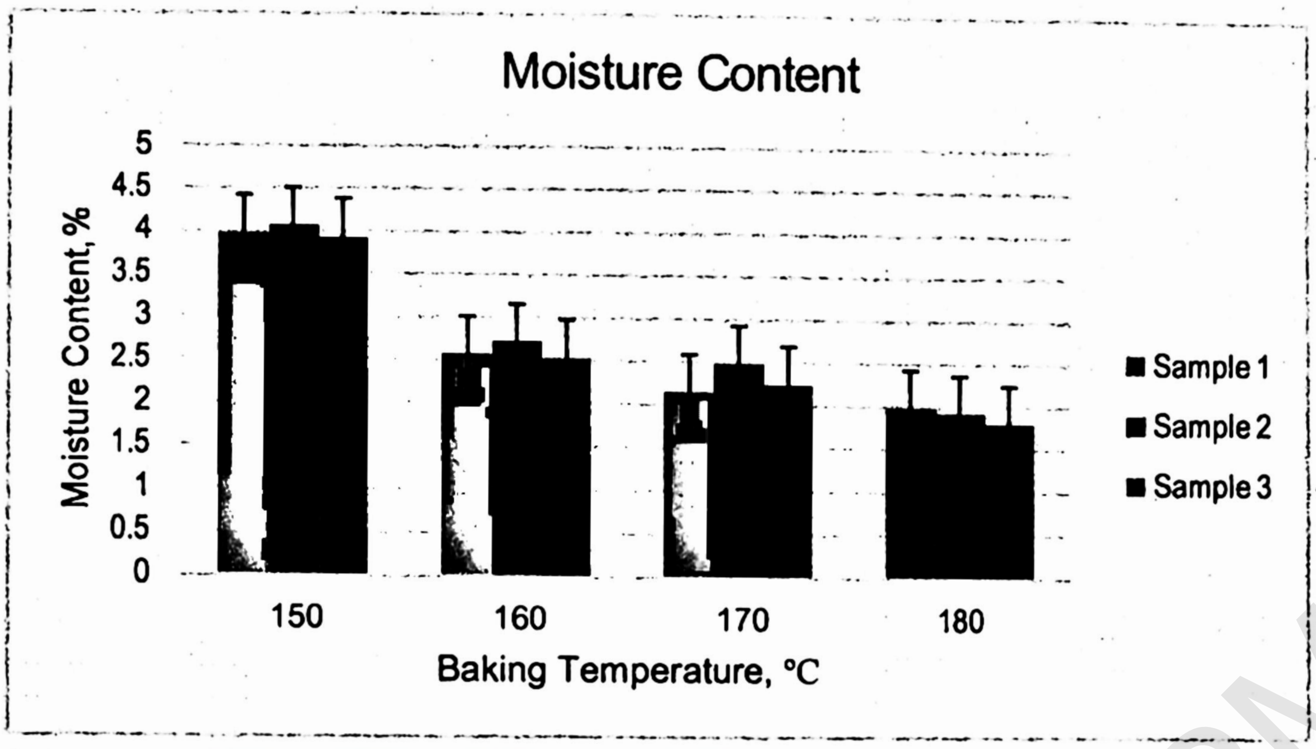

Figure 4.14: Graph of moisture content of ice cream wafer cone at different baking temperature and baking time for 4 minutes

Based on Figure 4.15, the moisture content of the ice cream wafer cone of sample 1 which the batter was mixed with the water of 14°C baked for 5 minutes, the wafer baked at 150°C has the higher value of moisture content compared to the ice cream wafer cone that has been baked at 160, 170 and 180°C. The value of moisture content for the ice cream wafer cone baked at 150°C for 5 minutes was 3.12 while the value of moisture content for the ice cream wafer cone at 160, 170 and 180°C were 2.16, 1.95 and 1.52 respectively. The value of moisture content for the ice cream wafer cone that has been baked at 180°C was lower compared to 150, 160 and 170°C because the ice cream wafer cone was baked at higher temperature compared to the ice cream wafer cone baked at 150, 160 and 170°C.

The moisture content of the ice cream wafer cone of sample 2 which the batter was mixed with the water of 20°C baked for 5 minutes, the wafer baked at 150°C has the higher value of moisture content compared to the ice cream wafer cone that has been baked at 160, 170 and 180°C. The value of moisture content for the ice cream wafer cone baked at 150°C for 5 minutes was 3.38 while the value of moisture content for the ice cream wafer cone at 160, 170 and 180°C were 4.09, 3.23 and 2.91 respectively. The value of moisture content for the ice cream wafer cone that has been baked at 180°C was lower compared to 150, 160 and 170°C because the ice cream wafer cone was baked at higher temperature compared to the ice cream wafer cone baked at 150, 160 and 170°C.

The moisture content of the ice cream wafer cone of sample 3 which the batter was mixed with the water of 26°C baked for 5 minutes, the wafer baked at 150°C has the higher value of moisture content compared to the ice cream wafer cone that has been baked at 160, 170 and 180°C. The value of moisture content for the ice cream wafer cone baked at 150°C for 5 minutes was 3.24 while the value of moisture content for the ice cream wafer cone at 160, 170 and 180°C were 2.23, 2.27 and 1.62 respectively. The value of moisture content for the ice cream wafer cone that has been baked at 180°C was lower compared to 150, 160 and 170°C because the ice cream wafer cone was baked at higher temperature compared to the ice cream wafer cone baked at 150, 160 and 170°C.

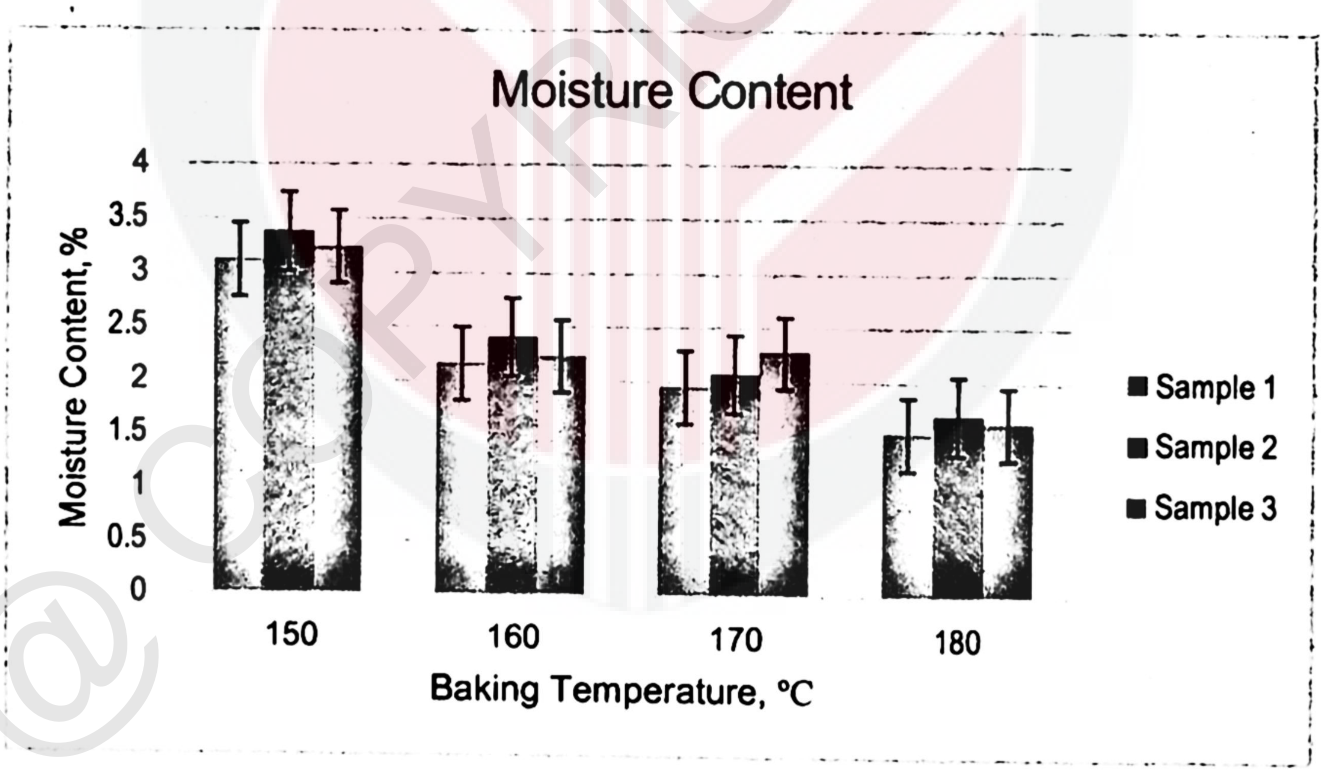

Figure 4.15: Graph of moisture content of ice cream wafer cone at different baking temperature and baking time for 5 minutes

4.4.1 Comparison between the samples and commercial ice cream wafer cone on moisture content

Comparing the moisture content of the ice cream wafer cone of Sample 1 that has use temperature of water at 14°C and commercial ice cream wafer cone, the moisture content of the ice cream wafer cone that has been baked at 160°C and 170°C for 3 minutes and ice cream wafer cone baked at 150°C for 4 minutes.

Comparing the moisture content of the ice cream wafer cone of Sample 2 that has use temperature of water at 20°C and commercial ice cream wafer cone, the moisture content of the ice cream wafer cone that has been baked at 150°C for 4 minutes and ice cream wafer cone baked at 160°C for 3 minutes.

Comparing the moisture content of the ice cream wafer cone of Sample 3 that has use temperature of water at 26°C and commercial ice cream wafer cone, the moisture content of the ice cream wafer cone that has been baked at 150°C for 4 minutes.

The result showed that when the baking temperature was higher, the moisture content will be lower and when the baking time was higher, the moisture content will be lower. The moisture content of the ice cream wafer cone that has been baked for a shorter time at any temperature were higher compared to the ice cream wafer cone that has been baked for a longer time at any temperature for all types of Sample. Based on the result obtained, it can be seen that all the moisture content value were in the range of 1%-6%. Hence, the moisture content value was acceptable since it was in the range of moisture content that has been suggested by Cauvain and Young where the wafer sheets keep their typical crisp texture up to 5-6% moisture content. According to Ergun et al. (2010), the moisture content gives a critical impact on the shelf life of the ice cream cone. Navarrete et al. (2004) recommended moisture levels between 6% and 11% for obtaining an acceptable crispy wafer. This range was quite high and was not applicable to wafer lines. Wafer crispiness was regarded as the most important textural property. Moisture level affects the texture of wafers by softening the starch-protein matrix that alters the strength of the wafer sheet (Katz & Labuza, 1981).

Table 4.6: Moisture analysis of commercial ice cream wafer cone

Sample	Moisture Content, %
Commercial Ice Cream Wafer Cone	4.23

4.5 Effect of baking temperature and time on colour of the ice cream wafer cone

According to Dogan (2006), wafer colour changed depending on the baking temperature and ingredients in the formulae. In the study, the primary factor affecting wafer colour was baking temperature, followed by water level. Colour and its homogeneity affect consumer preferences. Consumers prefer light-coloured wafers. Meaning that, the high-level value of L^* resulted in a lighter colour for the ice cream cone. The lightness value, L^*, represents the darkest black at $L^* = 0$, and the brightest white at $L^* = 100$. The colour channels, a^* and b^*, represent true neutral grey values at $a^* = 0$ and $b^* = 0$. The a^* axis represents the green–red component, with green in the negative direction and red in the positive direction. The b^* axis represents the blue-yellow component, with blue in the negative direction and yellow in the positive direction. In this section, the total colour difference, ΔE were calculated in order to compare which Sample has the smallest total colour difference between the optimized ice cream cone and the commercial ice cream cone.

Based on Table 4.7, among the colour parameters, L^* value was 60.74, a^* value was 8.04, and b^* value was 27.65.

Table 4.7: Total colour difference for commercial ice cream wafer cone

Sample	L*	a*	b*
Commercial ice cream wafer cone	60.74	8.04	27.65

Based on Figure 4.16, the total colour difference of the ice cream wafer cone of sample 1 which the batter was mixed with the water of 14°C baked for 3 minutes, the wafer baked at 150°C has the higher value of total colour difference compared to the ice cream wafer cone that has been baked at 160, 170 and 180°C. The value of total colour difference for the ice cream wafer cone baked at 150°C for 3 minutes was 7.01 while the value of total colour difference for the ice cream wafer cone at 160, 170 and 180°C were 5.58, 4.74 and 4.01 respectively. The value of total colour difference for the ice cream wafer cone that has been baked at 180°C was lower compared to 150, 160 and 170°C because the ice cream wafer cone was baked at higher temperature compared to the ice cream wafer cone baked at 150, 160 and 170°C for a shorter time which resulted in the suitable colour of the ice cream wafer cone while the ice cream wafer cone baked at 150°C has a high value of total colour difference because the wafer was not fully baked due to the shorter time of baking at lower temperature. Hence, the colour of the ice cream wafer cone baked at 150°C was lighter.

The total colour difference of the ice cream wafer cone of sample 2 which the batter was mixed with the water of 20°C baked for 3 minutes, the wafer baked at 150°C has the higher value of total colour difference compared to the ice cream wafer cone that has been baked at 160, 170 and 180°C. The value of total colour difference for the ice cream wafer cone baked at 150°C for 3 minutes was 7.20 while the value of total colour difference for the ice cream wafer cone at 160, 170 and 180°C were 4.25, 4.81 and 4.36 respectively. The value of total colour difference for the ice cream wafer cone that has been baked at 160°C was lower compared to

150, 170 and 180°C because the ice cream wafer cone was baked at suitable temperature compared to the ice cream wafer cone baked at 150, 170 and 180°C for a shorter time which resulted in the suitable colour of the ice cream wafer cone while the ice cream wafer cone baked at 150°C has a high value of total colour difference because the wafer was not fully baked due to the shorter time of baking at lower temperature. Hence, the colour of the ice cream wafer cone baked at 150°C was lighter.

The total colour difference of the ice cream wafer cone of sample 3 which the batter was mixed with the water of 26°C baked for 3 minutes, the wafer baked at 150°C has the higher value of total colour difference compared to the ice cream wafer cone that has been baked at 160, 170 and 180°C. The value of total colour difference for the ice cream wafer cone baked at 150°C for 3 minutes was 9.37 while the value of total colour difference for the ice cream wafer cone at 160, 170 and 180°C were 2.64, 3.86 and 3.03 respectively. The value of total colour difference for the ice cream wafer cone that has been baked at 160°C was lower compared to 150, 170 and 180°C because the ice cream wafer cone was baked at suitable temperature compared to the ice cream wafer cone baked at 150, 170 and 180°C for a shorter time which resulted in the suitable colour of the ice cream wafer cone while the ice cream wafer cone baked at 150°C has a high value of total colour difference because the wafer was not fully baked due to the shorter time of baking at lower temperature. Hence, the colour of the ice cream wafer cone baked at 150°C was lighter.

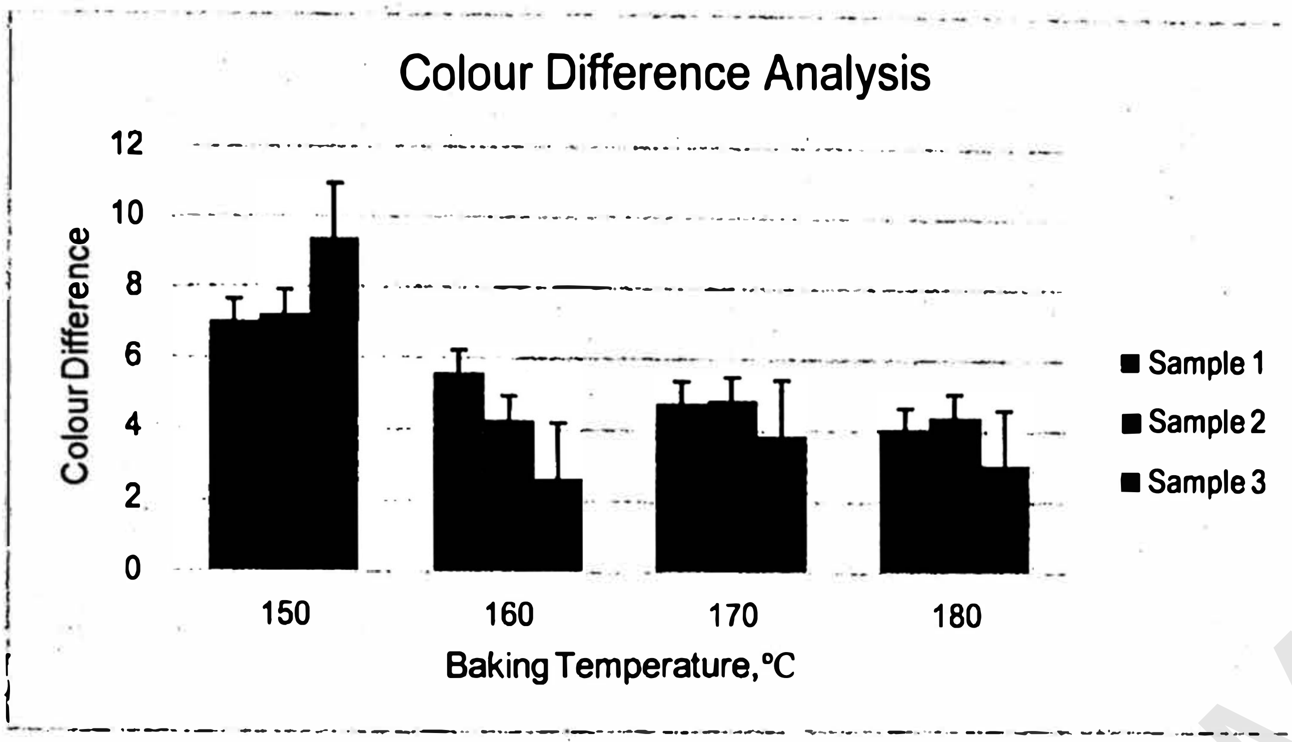

Figure 4.16: Graph of total colour difference of ice cream wafer cone at different baking temperature and baking time for 3 minutes

Based on Figure 4.17, the total colour difference of the ice cream wafer cone of sample 1 which the batter was mixed with the water of 14°C baked for 4 minutes, the wafer baked at 150°C has the higher value of total colour difference compared to the ice cream wafer cone that has been baked at 160, 170 and 180°C. The value of total colour difference for the ice cream wafer cone baked at 150°C for 4 minutes was 7.71 while the value of total colour difference for the ice cream wafer cone at 160, 170 and 180°C were 5.89, 7.38 and 5.59 respectively. The value of total colour difference for the ice cream wafer cone that has been baked at 180°C was lower compared to 150, 160 and 170°C because the ice cream wafer cone was baked at higher temperature compared to the ice cream wafer cone baked at 150, 160 and 170°C for a shorter time which resulted in the suitable colour of the ice cream wafer cone while the ice cream wafer cone baked at 150°C has a high value of total colour difference because the wafer was not fully baked due to the shorter time of baking at lower temperature. Hence, the colour of the ice cream wafer cone baked at 150°C was lighter.

The total colour difference of the ice cream wafer cone of sample 2 which the batter was mixed with the water of 20°C baked for 4 minutes, the wafer baked at 150°C has the higher value of total colour difference compared to the ice cream wafer cone that has been baked at 160, 170 and 180°C. The value of total colour difference for the ice cream wafer cone baked at 150°C for 4 minutes was 8.83 while the value of total colour difference for the ice cream wafer cone at 160, 170 and 180°C were 4.25, 4.81 and 4.36 respectively. The value of total colour difference for the ice cream wafer cone that has been baked at 160°C was lower compared to 150, 170 and 180°C because the ice cream wafer cone was baked at suitable temperature compared to the ice cream wafer cone baked at 150, 170 and 180°C for a shorter time which resulted in the suitable colour of the ice cream wafer cone while the ice cream wafer cone baked at 150°C has a high value of total colour difference because the wafer was not fully baked due to the lower baking temperature which resulted in lighter colour of wafer cone.

The total colour difference of the ice cream wafer cone of sample 3 which the batter was mixed with the water of 26°C baked for 4 minutes, the wafer baked at 150°C has the higher value of total colour difference compared to the ice cream wafer cone that has been baked at 160, 170 and 180°C. The value of total colour difference for the ice cream wafer cone baked at 150°C for 4 minutes was 8.66 while the value of total colour difference for the ice cream wafer cone at 160, 170 and 180°C were 3.76, 4.75 and 3.14 respectively. The value of total colour difference for the ice cream wafer cone that has been baked at 180°C was lower compared to 150, 160 and 170°C because the ice cream wafer cone was baked at higher temperature compared to the ice cream wafer cone baked at 150, 160 and 170°C for a shorter time which resulted in the suitable colour of the ice cream wafer cone while the ice cream wafer cone baked at 150°C has a high value of total colour difference because the wafer was not fully baked due to the shorter time of baking at lower temperature. Hence, the colour of the ice cream wafer cone baked at 150°C was lighter.

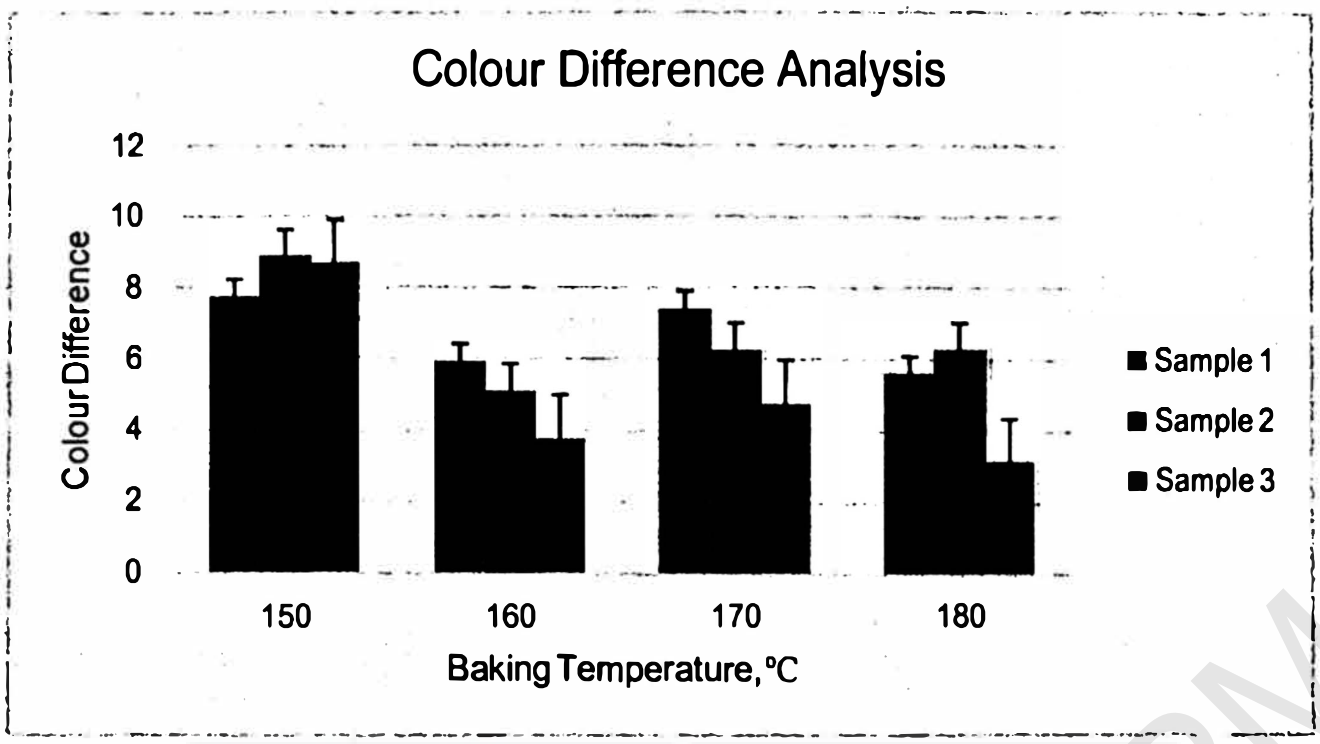

Figure 4.17: Graph of total colour difference of ice cream wafer cone at different baking temperature and baking time for 4 minutes

Based on Figure 4.18, the total colour difference of the ice cream wafer cone of sample 1 which the batter was mixed with the water of 14°C baked for 5 minutes, the wafer baked at 150°C has the higher value of total colour difference compared to the ice cream wafer cone that has been baked at 160, 170 and 180°C. The value of total colour difference for the ice cream wafer cone baked at 150°C for 5 minutes was 7.71 while the value of total colour difference for the ice cream wafer cone at 160, 170 and 180°C were 6.15, 7.43 and 5.90 respectively. The value of total colour difference for the ice cream wafer cone that has been baked at 180°C was lower compared to 150, 160 and 170°C because the ice cream wafer cone was baked when the moulding's was not fully heated at 180°C which resulted in suitable colour of ice cream wafer cone while the ice cream wafer cone baked at 150°C has a high value of total colour difference because the wafer cone was baked at lower temperature. Hence, the colour of the ice cream wafer cone baked at 150°C was lighter.

The total colour difference of the ice cream wafer cone of sample 2 which the batter was mixed with the water of 20°C baked for 5 minutes, the wafer baked at 150°C has the higher value of total colour difference compared to the ice cream wafer cone that has been baked at

160, 170 and 180°C. The value of total colour difference for the ice cream wafer cone baked at 150°C for 5 minutes was 9.87 while the value of total colour difference for the ice cream wafer cone at 160, 170 and 180°C were 5.99, 9.45 and 9.15 respectively. The value of total colour difference for the ice cream wafer cone that has been baked at 160°C was lower compared to 150, 170 and 180°C because the ice cream wafer cone was baked at suitable temperature compared to the ice cream wafer cone baked at 150, 160 and 170°C for a longer time which resulted in the suitable colour of the ice cream wafer cone while the ice cream wafer cone baked at 150°C has a high value of total colour difference because the wafer was baked lower temperature. Hence, the colour of the ice cream wafer cone baked at 150°C was lighter.

The total colour difference of the ice cream wafer cone of sample 3 which the batter was mixed with the water of 26°C baked for 5 minutes, the wafer baked at 150°C has the higher value of total colour difference compared to the ice cream wafer cone that has been baked at 160, 170 and 180°C. The value of total colour difference for the ice cream wafer cone baked at 150°C for 5 minutes was 12.60 while the value of total colour difference for the ice cream wafer cone at 160, 170 and 180°C were 10.32, 6.16 and 4.14 respectively. The value of total colour difference for the ice cream wafer cone that has been baked at 180°C was lower compared to 150, 160 and 170°C because the ice cream wafer cone was baked when the moulding's was not fully heated at 180°C which resulted in suitable colour of ice cream wafer cone while the ice cream wafer cone baked at 150°C has a high value of total colour difference because the wafer cone was baked at lower temperature. Hence, the colour of the ice cream wafer cone baked at 150°C was lighter.

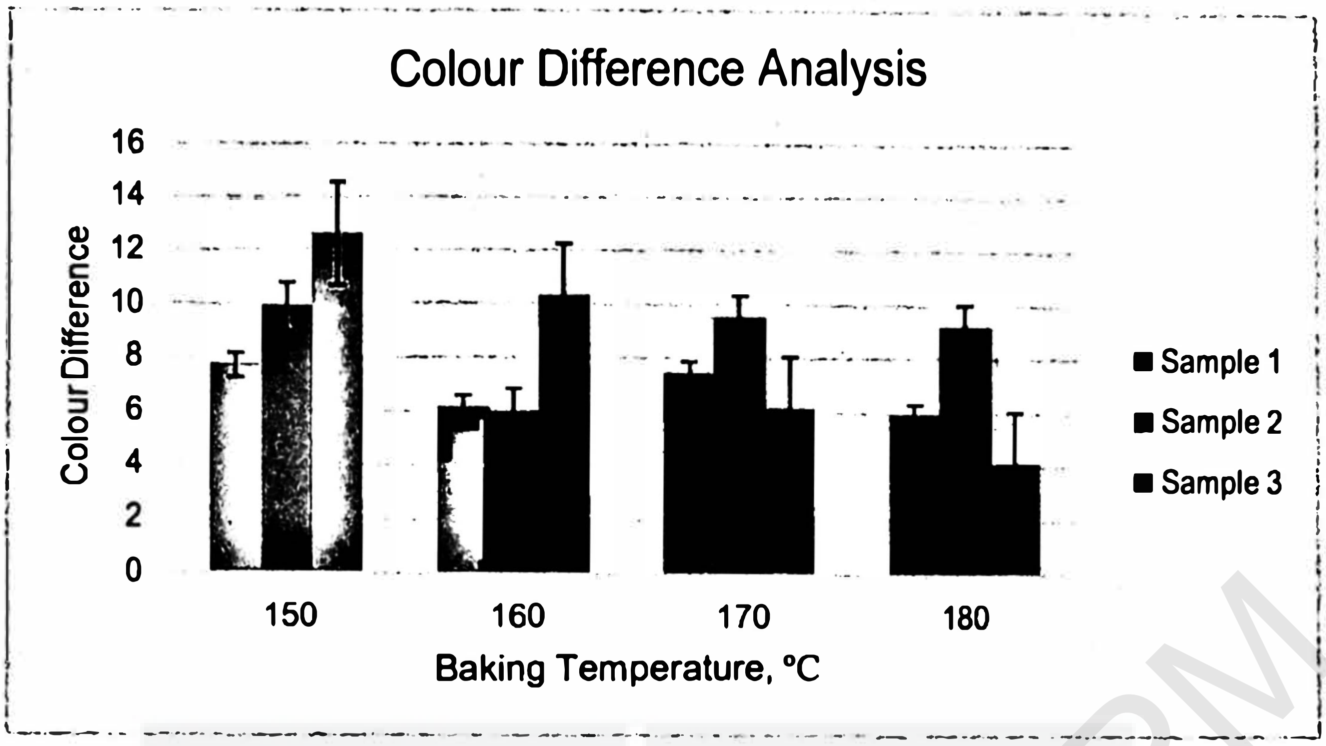

Figure 4.18: Graph of total colour difference of ice cream wafer cone at different baking temperature and baking time for 5 minutes

4.5.1 Comparison between the samples and commercial ice cream wafer cone on colour difference

Comparing the colour difference between the ice cream wafer cone of Sample 1 that has use temperature of water at 14°C and commercial ice cream wafer cone, the colour difference of the ice cream wafer cone that has been baked at 160, 170°C and 180°C for 3 minutes were small which were 5.58, 4.74 and 4.01 respectively.

Comparing the colour difference between the ice cream wafer cone of Sample 2 that has use temperature of water at 20°C and commercial ice cream wafer cone, the colour difference of the ice cream wafer cone that has been baked at 160, 170°C and 180°C for 3 minutes were small which were 4.25, 4.81 and 4.36 respectively.

Comparing the colour difference between the ice cream wafer cone of Sample 3 that has use temperature of water at 26°C and commercial ice cream wafer cone, the colour difference of the ice cream wafer cone that has been baked at 160, 170°C and 180°C for 3 minutes were small which were 2.64, 3.86 and 3.03 respectively.

The result showed that when the baking temperature was higher, the colour difference between the ice cream wafer cone and commercial ice cream wafer cone will be higher. Among the three types of Sample with different temperature of water, the ice cream wafer cone that has been baked for a shorter time at any temperature resulted in the smaller value of the total colour difference between the ice cream wafer cone and commercial ice cream wafer cone. According to Dogan (2006), wafer colour changed depending on the baking temperature and ingredients in the formula. In the study, the primary factor affecting wafer colour was baking temperature. Colour and its homogeneity affect consumer preferences. Consumers prefer light-coloured wafers. That was why the ice cream wafer cone that has the small value of the colour differences between the ice cream wafer cone and commercial ice cream wafer cone was good.

4.6 Summary Data

Table 4.8 showed the summary for the Sample that has a nearer value of properties to the properties of commercial ice cream wafer cone. The summary was made based on the data obtained for each analysis that had been done and recorded in the appendix 10-15. Based on Table 6, it can be concluded that the ice cream wafer cone of Sample 2.0 that has been baked at 160°C for 4 minutes has the nearest value the commercial ice cream wafer cone of each properties. As for Sample 1, the value of brittleness and toughness has a bigger difference of value from the commercial ice cream wafer cone while the Sample 3, the ice cream wafer cone need a very high force in order to break the ice cream wafer cone which means the difference between the hardness of ice cream wafer cone for Sample 3 and the commercial ice cream wafer cone were quite larger. That was why the ice cream wafer cone of Sample 2 was the most suitable to be used in order to make a quite similar ice cream wafer cone to the commercial ice cream wafer cone.

Table 4 8: Summary table for sample that have nearer value to the ice cream wafer cone for each analysis

Comparing with commercial ice cream wafer cone		
Sample	Baking Temperature, ºC	Baking Time, minutes
1	160	3
2	160	4
3	150	4

CHAPTER 5: CONCLUSION AND RECOMMENDATION

5.1 Conclusion

In terms of hardness, among the three different types of the Sample that have a different temperature of water, Sample 2 has the lower value of the force required by the ice cream wafer cone in order to break the ice cream wafer cone compared to Sample 1 and 3.

In terms of brittleness, among the three different types of the Sample that have a different temperature of water, Sample 2 has the higher value of brittleness of the ice cream wafer cone compared to Sample 1 and 3.

In terms of toughness, among the three different types of the Sample that have a different temperature of water, Sample 2 has the medium value of toughness of the ice cream wafer cone which was not too high and not too low compared to Sample 1 and 3. The batter with lower temperature resulted in a low value of toughness property.

In terms of crispiness, among the three different types of the Sample that have a different temperature of water, Sample 2 has the higher value of crispiness of the ice cream wafer cone which was not too high and not too low compared to Sample 1 and 3. The ice cream wafer cone bake at a lower temperature will have a higher value of crispiness compared to the ice cream wafer cone baked at higher temperature due to the moisture content of the ice cream wafer cone.

In terms of moisture content, the moisture content of the ice cream wafer cone that has been baked for a shorter time at any temperature were higher compared to the ice cream wafer cone that has been baked for a longer time at any temperature for all types of Sample.

In terms of colour analysis, among the three types of Sample with different temperature of water, the ice cream wafer cone that has been baked for a shorter time at any temperature resulted in the smaller value of the total colour difference between the ice cream wafer cone and commercial ice cream wafer cone.

In conclusion, the value of brittleness and toughness of Sample 1 was a bigger difference between the value of the commercial ice cream wafer cone while the Sample 3, the ice cream wafer cone need a very high force in order to break the ice cream wafer cone which means the difference between the hardness of ice cream wafer cone for Sample 3 and the commercial ice cream wafer cone were quite larger. That was why the ice cream wafer cone of Sample 2 was the most suitable to be used in order to make a quite similar ice cream wafer cone to the commercial ice cream wafer cone.

5.1 Recommendations for Further Studies

There were a few recommendations that can be done in order to improve this study. For the next approach that can be done is by using the finalized Sample chose to be baked on the ice cream wafer cone moulding machine. Hence, the comparison between the ice cream wafer cone and the commercial ice cream wafer cone will be more accurate and effective. This is because the probe of analysing the textural properties of both ice cream wafer cone used will be the same.

Next, the water activity content analysis should be conducted by using water activity analyzer in order to determine the limit of the water activity content of the ice cream wafer cone to prevent the ice cream wafer cone from become soggy.

Lastly, the batter mixture can be developed into powder mixture. Hence the production of ice cream wafer cone will be effective since the Sample of making the ice cream wafer cone were the same for all batch of the production.

REFERENCES

Bringhurst, T. A. & Brosnan, J. (2014). Scotch whisky: Raw material selection and processing. In I. Russell & G. Stewart (Eds.), Whiskey technology, production and marketing (2nd edn, Chapter 6, pp. 49–122). Oxford, UK: Elsevier

Cauvain, S. P. & Young, L. S. (2009). Bakery Food Manufacture and Quality: Water Control and Effects, Second edn., pp 87-88.

Dalgleish, T. et. al (2007). Journal of Experimental Psychology: General, 136(1), 23–42.

Dogan, I. (2006). Factors affecting wafer sheet quality. International Journal of Food Science and Technology, 41(5), 569–576.

Farahnaky, A., & Hill, S. E. (2007). The Effect of Salt, Water and Temperature on Wheat Dough Rheology. Journal of Texture Studies, 38(4), 499–510.

Ghotra, B.S., Dyal, S.D., Narine, S.S., 2002. Lipid shortenings: a review. Food Res. Int. 35, 1015e1048.

Guadarrama- Lezama, A., Y., et. Al (2016). Thermal and rheological properties of sponge cake made with native corn starch in partial or total replacement of wheat flour. *LWT- Food Science and Technology*, 70, 46-54.

Hesso, N., Garnier, C., Loisel, C., Chevallier, S., Bouchet, B., & Le-Bail, A. (2015). Formulation effect study on batter and cake microstructure: Correlation with rheology and texture. Food Structure, 5, 31–41.

Huang, V. T, Luebberes, S. T, Lindamood, J. B, & Hansen, P. M. T (1989). Ice Cream Cone Baking 2. Textural Characteristics of Rolled Sugar Cones. Topic in Catalysis, 3(1), 41-55.

Huang, V. T.(1981a). The Art and Science of Ice Cream Cone Baking, pp.173

Huang, V. T.(1981b). The Art and Science of Ice Cream Cone Baking, *Social Change,* pp.173

Huber, R., & Schoenlechner, R. (2017). Waffle production: influence of batter ingredients on sticking of fresh egg waffles at baking plates—Part I: effect of starch and sugar components. Food Science and Nutrition, 5(3), 504–512. https://doi.org/10.1002/fsn3.424

Kigozi, J., Banadda N., Byaruhanga Y., Kaaya A., & Musoke L.(2014). Optimization of Texture in Dorghum Ice Cream Cone Production using Sensory Analysis, pp. 18-21

Manley, D. J. R. (2000). Technology of Biscuits, crakers and Cookies, 3rd edn. Cambridge, UK: Woodheaf Publishing. Pp: 290-306.

Miller, R. (2016). Leavening agents. In B. Caballero, P. M. Finglas, & F. Toldra (Eds.), Encyclopedia of food and health (pp. 523–528). Oxford, UK: Elsevier, Academic Press.

Mohamed, S., Hamid, N. A. and Hamid, M. A. (1998), Food components affecting the oil absorption and crispness of fried batter, Journal of the Science of Food and Agriculture 78(1), 39–45.

Navarrete, N.M., Moraga, G., Talens, P. & Chiralt, A. (2004). Water sorption and the plasticization effect in wafers. International Journal of Food Science and Technology, 39, 555–562.

Oliver, G., & Sahi, S. S. (1995). Wafer batters: A rheological study. *Journal of the Science of Food and Agriculture*, *67*(2), 221–227.

Singh, J., Kaur, L., & McCarthy, O., J. (2007). Factors influencing the physico-chemical, morphological, thermal and rheological properties of some chemically modified starches for food applications. A review. *Food hydrocolloids,* 21(1), 1-22.

Tiefenbacher, K. (2009). Handbook of wafer technology. In House hand- book for Franz Haas Waffel- und Keksanlagen-Industrie GmbH, Leobendorf, Austria, p 1-C3

Vetter, J. L. (2003). Leavening Agents. Encyclopedia of Food Sciences and Nutrition, 2, 3485–3490

Vieira, M., Bommarito, S. & Takaki, P. (2014). Maximum Bite Force Analysis in Different Age Groups, International Archives of Otorhinolarymgology, 18(3).

Wang, S., Li C., Copeland L., Niu Q., & Wang S.(2015) Starch Retrogradation: A Comprehensive Review. *Comprehensive Reviews in Food Science and Food Safety,* 14(5), pp 568-585.

Zhang, L., Yang, M., Ji, H. & Ma, H. (2014). Some Physicochemical Properties of Starches and Their Influences on Colour, Texture and oil Content in Crusts Using a Deep-fat-fried Model. CYTA- Journal of Food, 12(4),347-354.

APPENDICES

Appendix 1: Hardness of ice cream wafer cone for different types of sample

Baking temperature (°C)	Baking time (Minutes)	Maximum force (Hardness), g Average (±□□) Sample 1	Maximum force (Hardness), g Average (±□□) Sample 2	Maximum force (Hardness), g Average (±□□) Sample 3
150	3	523.12(±27.64)	460.3(±41.75)	898.93(±44.43)
	4	650.02(±245.29)	580.07(±64.3)	739.80(±22.1)
	5	593.37 (±28.63)	510.56(±75.94)	637.62(±71.53)
160	3	331.31(±219.26)	655.51(±30.56)	575.80(±169.78)
	4	610.03(±46.98)	382.57(±14.56)	606.37(±40.09)
	5	627.62(±63.33)	472.89(±77.63)	867.73(±446.30)
170	3	453.7(±26.33)	466.82(±47.70)	695.17(±104.03)
	4	466.24(±48.28)	510.3(±13.15)	744.56(±113.43)
	5	658.15(±71.28)	676.25(±4.70)	1027.20(±531.90)
180	3	439.99(±80.02)	563.21(±45.82)	962.24(±122.55)
	4	573.52(±17.78)	657.75(±29.79)	1019.57(±106.22)
	5	666.46(±42.97)	851.95(±23.19)	1029.17(±67.52)

Appendix 2: Brittleness of ice cream wafer cone for different types of sample

Baking temperature (ºC)	Baking time (Minutes)	Distance at maximum force (Brittleness), g.ms Average (±□□) Sample 1	Distance at maximum force (Brittleness), g.ms Average (±□□) Sample 2	Distance at maximum force (Brittleness), g.ms Average (±□□) Sample 3
150	3	0.39 (±0.07)	0.71 (±0.18)	1.00 (±0.015)
	4	0.42 (±0.09)	0.84 (±0.13)	0.80 (±0.22)
	5	0.25 (±0.02)	1.12 (±0.55)	0.69 (±0.12)
160	3	0.25 (±0.19)	0.57 (±0.19)	1.33 (±0.54)
	4	0.35 (±0.06)	0.72 (±0.1)	0.48 (±0.03)
	5	0.48 (±0.09)	0.47 (±0.05)	0.57 (±0.09)
170	3	0.39 (±0.05)	0.42 (±0.11)	0.56 (±0.16)
	4	0.45 (±0.09)	0.55 (±0.33)	0.72 (±0.15)
	5	0.37 (±0.05)	0.41 (±0.09)	0.96 (±0.25)
180	3	0.48 (±0.03)	0.40 (±0.01)	0.77 (±0.16)
	4	0.36 (±0.08)	0.35 (±0.06)	0.70 (±0.16)
	5	0.39 (±0.07)	0.34 (±0.04)	1.01 (±0.18)

Appendix 3: Toughness of ice cream wafer cone for different types of sample

Baking temperature (°C)	Baking time (Minutes)	Area to maximum force (Toughness) Average (±□□) Sample 1	Area to maximum force (Toughness) Average (±□□) Sample 2	Area to maximum force (Toughness) Average (±□□) Sample 3
150	3	53.12 (±16.29)	87.77 (±29.36)	144.71 (±23.22)
	4	63.40 (±46.89)	139.34 (±21.67)	113.31 (±26.50)
	5	31.07 (±3.28)	110.69 (±56.7)	99.10 (±28.65)
160	3	36.97 (±16.12)	96.79 (±25.15)	104.62 (±1.44)
	4	51.20 (±3.88)	73.12 (±21.03)	66.16 (±6.64)
	5	72.54 (±20.61)	50.24 (±11.22)	114.03 (±92.45)
170	3	36.68 (±9.77)	51.72 (±12.60)	82.75 (±19.63)
	4	51.83 (±17.05)	69.16 (±47.60)	87.00 (±22.96)
	5	55.10 (±5.92)	57.89 (±19.33)	187.70 (±136.78)
180	3	52.82 (±12.55)	51.25 (±5.05)	141.55 (±53.12)
	4	45.45 (±10.58)	55.19 (±5.65)	153.43 (±38.14)
	5	61.27 (±10.65)	64.94 (±14.55)	149.71 (±54.00)

Appendix 4: Crispiness of ice cream wafer cone for different types of sample

Baking temperature (ºC)	Baking time (Minutes)	Number of peaks (Crispiness) Average (±□□) Sample 1	Number of peaks (Crispiness) Average (±□□) Sample 2	Number of peaks (Crispiness) Average (±□□) Sample 3
150	3	6.00(±2.00)	7.33(±2.08)	14.33(±15.31)
	4	8.25(±5.50)	14.67(±2.08)	18.00(±15.1)
	5	6.00(±4.58)	10.00(±9.54)	12.67(±3.79)
160	3	7.75(±4.57)	10.00(±6.24)	7.00(±2.00)
	4	5.00(±4.36)	8.67(±2.08)	9.33(±5.03)
	5	3.00(±1.73)	4.00(±0.00)	6.33(±1.15)
170	3	4.33(±1.53)	7.33(±4.04)	5.67(±4.73)
	4	2.67(±1.15)	7.00(±6.24)	9.67(±11.55)
	5	3.00(±1.00)	6.67(±1.15)	5.33(±1.53)
180	3	3.33(±1.53)	5.33(±2.30)	11.67(±7.37)
	4	7.67(±8.08)	10.00(±1.00)	12.67(±5.13)
	5	7.00(±6.08)	10.33(±7.64)	44.67(±6.66)

Appendix 5: Moisture content of ice cream wafer cone for different types of sample

Baking temperature (°C)	Baking time (Minutes)	Average moisture content (%) Sample 1	Average moisture content (%) Sample 2	Average moisture content (%) Sample 3
150	3	5.63	5.51	5.76
	4	3.97	4.05	3.92
	5	3.12	3.38	3.24
160	3	3.95	4.09	3.45
	4	2.56	2.71	2.52
	5	2.16	2.41	2.23
170	3	3.70	3.23	3.55
	4	2.14	2.47	2.24
	5	1.95	2.07	2.27
180	3	2.75	2.91	2.44
	4	1.98	1.92	1.80
	5	1.52	1.69	1.62

Appendix 6: L-value of ice cream wafer cone for different types of sample

Baking temperature (°C)	Baking time (Minutes)	*L** Sample 1	*L** Sample 2	*L** Sample 3
150	3	66.71	66.80	72.37
	4	65.56	68.94	68.63
	5	65.60	69.16	69.42
160	3	64.42	63.56	69.78
	4	64.16	65.05	63.83
	5	64.29	65.38	63.09
170	3	65.72	66.87	63.79
	4	62.96	63.50	65.08
	5	62.86	64.26	66.68
180	3	59.12	64.05	62.83
	4	60.37	62.07	63.52
	5	59.21	61.96	61.21

Appendix 7: a-value of ice cream wafer cone for different types of sample

Baking temperature (ºC)	Baking time (Minutes)	*a** Sample 1	*a** Sample 2	*a** Sample 3
150	3	9.15	6.65	3.72
	4	9.55	6.10	7.56
	5	9.53	7.14	6.96
160	3	9.85	9.73	6.55
	4	10.03	9.48	8.86
	5	9.95	8.56	8.87
170	3	9.38	9.14	9.30
	4	10.60	9.92	8.21
	5	10.42	9.11	7.94
180	3	11.00	35.83	9.48
	4	11.30	31.10	9.63
	5	11.66	32.97	10.13

Appendix 8: b-value on ice cream wafer cone for Different Types of Sample

Baking temperature (°C)	Baking time (Minutes)	*b** Sample 1	*b** Sample 2	*b** Sample 3
150	3	32.40	31.28	29.89
	4	32.51	30.30	31.20
	5	33.45	32.73	31.01
160	3	31.43	30.34	32.40
	4	32.02	31.55	29.63
	5	32.30	29.60	28.53
170	3	33.00	34.76	29.66
	4	34.21	31.12	29.57
	5	31.16	32.86	29.29
180	3	29.82	35.83	29.31
	4	32.18	31.10	30.27
	5	32.05	32.97	29.94

Appendix 9: Colour difference of ice cream wafer cone for different types of sample

Baking temperature (°C)	Baking time (Minutes)	Colour difference (ΔE) Sample 1	Colour difference (ΔE) Sample 2	Colour difference (ΔE) Sample 3
150	3	7.01	7.20	9.37
	4	7.71	8.83	8.66
	5	7.71	9.87	12.6
160	3	5.58	4.25	2.64
	4	5.89	5.06	3.76
	5	6.15	5.99	10.32
170	3	4.74	4.81	3.86
	4	7.38	6.23	4.75
	5	7.43	9.45	6.16
180	3	4.01	4.36	3.03
	4	5.59	6.26	3.14
	5	5.90	9.15	4.14

Appendix 10: Summary table for sample that have nearer value to the commercial ice cream wafer cone for hardness analysis

Type of analysis	Comparison with commercial ice cream wafer cone		
	Samples	Baking temperature, °C	Baking time, minutes
Hardness	1.0	160	3
		170	3
			4
		180	3
	2.0	150	3
		160	4
			5
		170	3

Appendix 11: Summary table for sample that have nearer value to the ice cream wafer cone for brittleness analysis

Type of analysis	Comparison with commercial ice cream wafer cone		
	Samples	Baking temperature, °C	Baking time, minutes
Brittleness	2.0	150	4
			5
		160	4
	3.0	150	4
		160	3

Appendix 12: Summary table for sample that have nearer value to the ice cream wafer cone for toughness analysis

Type of analysis	Comparison with commercial ice cream wafer cone		
	Samples	Baking temperature, °C	Baking time, minutes
Toughness	1.0	160	5
	2.0	150	4
			5
		160	3
	3.0	150	4
			5
		160	3
			5

Appendix 13: Summary table for sample that have nearer value to the commercial ice cream wafer cone for crispiness analysis

Type of analysis	Comparison with commercial ice cream wafer cone		
	Samples	Baking temperature, °C	Baking time, minutes
Crispiness	1.0	150	4
		160	3
		180	4
	2.0	150	4
			5
		160	3
			4
	3.0	150	4
			5
		160	4
		170	4

Appendix 14: Summary table for sample that have nearer value to the commercial ice cream wafer cone for moisture analysis

Types of analysis	Comparison with commercial ice cream wafer cone		
	Samples	Baking temperature, ºC	Baking time, minutes
Moisture	1.0	150	4
		160	3
		170	3
	2.0	150	4
		160	3
	3.0	150	4

Appendix 15: Summary table for sample that have nearer value to the commercial ice cream wafer cone for colour analysis

Types of analysis	Comparison with commercial ice cream wafer cone		
	Samples	Baking temperature, ºC	Baking time, minutes
Colour	1.0	160	3
		170	3
		180	3
	2.0	160	3
		170	3
		180	3
	3.0	160	3
		170	3
		180	3