EFFECTS OF DIFFERENT EMULSIFIERS ON PHYSICOCHEMICAL, COLOR AND SENSORY ATTRIBUTES OF CAKE DURING STORAGE

A THESIS

BY

ALO MONI
STUDENT ID. 1405204
SESSION: 2014-2015
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MASTER OF SCIENCE (MS)
IN
FOOD PROCESSING AND PRESERVATION

DEPARTMENT OF FOOD PROCESSING AND PRESERVATION
HAJEE MOHAMMAD DANESH SCIENCE AND TECHNOLOGY UNIVERSITY, DINAJPUR-5200, BANGLADESH

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Submitted to the

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December, 2015

DEDICATED
TO MY
BELOVED PARENTS

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December, 2015 *The author*

ABSTRACT

The objectives of this study was to prepare cake with different emulsifiers such as ester of monoglyceride, glycerol monostearate and di sodium phosphate as well as the effects of those emulsifiers on physicochemical properties, color and sensory attributes of cake during storage. Cake prepared with emulsifiers had lower specific gravity than those of cake prepared without emulsifiers. Protein, fat and ash contents of cake were dependent on emulsifier types throughout the storage period. L^* values were decreased whereas a^*, b^* and firmness were increased for all samples after 30^{th} days of storage. Control samples were not acceptable after 15 days of storage. There was no significant difference in overall acceptability among all cakes prepared with emulsifiers. Therefore, results showed that good quality cake could be made with the ester of monoglyceride, glycerol mono stearate and di sodium phosphate and kept 30^{th} days without any nutritional changes.

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INTRODUCTION

CHAPTER I

INTRODUCTION

Cakes are sweet baked product consumed by the people in whole world. These are characterized by dense, tender and sweet taste. Cakes are delicious food liked by children and become popular among adults due to its convenience in carrying and eating as well. Moreover demand for ready to eat products like cake increase due to spread in education, woman at work and changing food habits of the consumers. Cake is one of the relished and palatable baked products which contain a combination of flour, sugar, eggs and butter or oil, with some liquid (typically milk or water) and leavening agents (such as yeast or baking powder). Cakes can be prepared with different types of stabilizers, emulsifier, humectants etc. These substances increase the keeping quality and overall acceptability of the cakes. Humectants keep the moisture into the cake which prevents drying out and humectants normally used in cakes are sorbitol, glycerol, propylene glycol etc. (Butt *et al.*, 2002). Various types of emulsifier such as glycerol monostearate, lecithin and sorbitan monostearate can also be used in the cake to suspending ingredients, incorporating air and providing stability (Sahi and Alava, 2003; Rahmati and Tehrani, 2014). Moreover, the emulsifiers also incorporate into cake to enhance emulsifying properties and extend cake softness by holding considerable amounts of moisture.

High volume, uniform crumb structure, tenderness, shelf life and tolerance to staling are the main criteria for the good quality of cake (Gomez *et al.*, 2007). Several studies have been shown that the cake quality characteristics could be enhanced by various emulsifier, humectants, stabilizer and different ingredients. Eggless cake properties such as moisture, specific gravity can be affected by distilled glycerol monostearate, lecithin and sorbitan monostearate (Rahmati and Tehrani, 2014). Glycerol monostearate and poly glycerol ester would affect the distribution and size of the air bubbles as well as decreased the fluidity in sponge cake (Sahi and Alava, 2003). The effects of gum arabic, guar gum, xanthan gum, carrageenan, hydroxyl-propylmethylcellulose in combination with glycerol monostearate and sodium stearoyl-2-lactylate on the quality characteristics of cakes have also been conducted by Ashwini, Jyotsna, and Indrani, (2009). Different preservatives such as potassium sorbate, sodium benzoate could be used in cake to prevent yeast and mold growth and also enhance its keeping quality (Guynot *et al.*, 2003).

On the other hand wheat flour quality can be varied due to genetic and environmental origin (Blaszczak *et al.*, 2004). Therefore, flour quality might be impacted on cake quality. There are not enough reports on effects of emulsifiers in cake such as ester of monoglyceride, glycerol monostearate and di sodium phosphate along with wheat flour, whole egg, preservatives and other ingredients during storage. Therefore the objectives of the present study were to

1 Preparation of cakes with different emulsifiers such as ester of monoglyceride, glycerol monostearate and di sodium phosphate.

2 Observation of the effects of the emulsifiers used in the cake on physical, compositional and color properties during storage.

3 To investigate the sensory attributes of cakes during storage.

CHAPTER II

REVIEW OF LITERATURE

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REVIEW OF LITERATURE

2.1 Production of wheat

Wheat (*Triticum aestivum)* is a cereal grain, originated from the Levant region of the Near East but now cultivating worldwide. Globally, wheat is the leading source of vegetable protein in human food, having higher protein content than other major cereals. The top five producing countries of the world's total wheat supply in 2005-06 are shown in Figure 2.1:

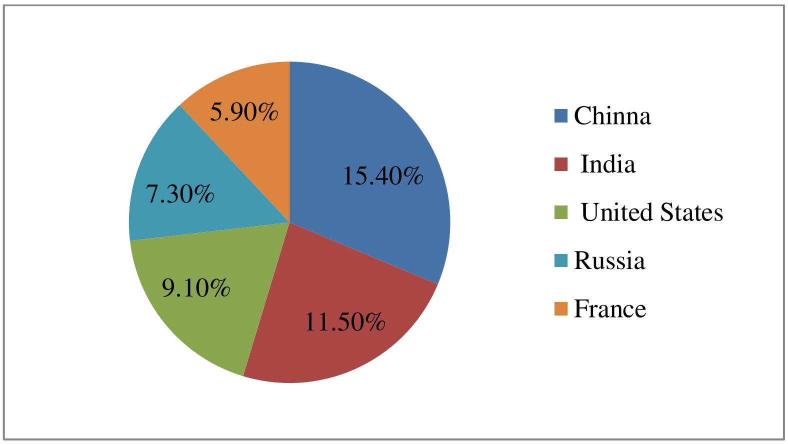

Figure 2.1: The top five wheat producing countries of the world in 2005-2006 (Nebraska Wheat Board, 2009)

Wheat was the second most-produced cereal in 2009; world production in that year was 682 million tons, after maize (817 million tons), and with rice as a close third (679 million tons). In 2012-2013 Bangladesh wheat production was 1.15 million tons from 410,000 hectares of land. Total production of wheat has been estimated 13,02,998 metric tons compared to 12,54,778 metric tons of the 2012-2013 (BBS, 2014). In 2013, world production of wheat was 713 million tons, making it the third most-produced cereal after maize (1,016 million tons) and rice (745 million tons).

2.2 Chemical compositions of wheat

Major chemical compositions of wheat are carbohydrate, protein, fat, fiber, water, vitamin B complex and minerals. Various chemical compositions of wheat are shown in Table 2.1.

Table 2.1 Chemical compositions of wheat

Chemical composition	Nutritional value per 100g
Carbohydrate	62
Protein	11.2
Fat	2.9
Ash	1.6
Dietary fiber	12.2
Water	10
Thiamin(B_1)	0.49mg
Riboflavin(B_2)	0.12mg
Niacin(B_3)	5.5mg
Pyridoxine (B_6)	0.30mg
Calcium	41mg
Iron	4.9mg
Potassium	293mg
Zinc	2.79mg
Energy	346kcal

Source: Shaheen *et al*., (2013)

2.2.1 Moisture content

Moisture content in flour is very important factor that varies normally ranges from 11–14%. When moisture content rises above 14 %, flour is susceptible to fungus and mold growth, flavor changes, enzyme activity, and insect infestation and also decreases shelf life. The moisture in wheat flour was lies 13.5% and 15.5%. Moisture is an important parameter when considering flour quality because it significantly affect the shelf life and help to increase the growth of the microbes (Syeda *et al*., 2012). Baljeet *et al*., (2010) studied on properties and incorporation of wheat flour for biscuit making and got 11.60% moisture content in wheat flour.

2.2.2 Protein

The baking quality of wheat flour is mainly depends on the quantity and quality of the flour proteins (Wujun *et al*., 2007). Protein is considered as the most important nutrient for humans and animals. The protein content of wheat grains may vary between 10% to 18% of the total dry matter (Zuzana Sramkova *et al*., 2009). The refining of flour greatly affects the protein content as it decreases from 14.2% at 100% extraction to 12.7% at 66% extraction of flour. It is the response to the removal of germ and aleurone layer as bran; both are relatively rich in protein. Flour protein content is not only an indicator of direct nutritional value, but is also an important influence on dough rheological properties. It is often related to bread-making quality (Wujun *et al*., 2007). Good bread flour has strong gluten that is indicated by high protein quantity (Campbell *et al*., 2001). In addition, wheat of high protein content usually commands a premium price because it is in demand for blending with low protein wheat for the production of bread flour (Wujun *et al*., 2007). It is well known that plant proteins are an alternative to proteins from animal sources for human nutrition (Molina *et al*., 2002).

2.2.3 Gluten

Wheat flour's strength depends on the gluten quality and content (Jirsa and Hruskova, 2005). Gluten, which is the special type of protein in wheat flour that forming a rubbery mass when wheat dough is washed to remove starch granules and water-soluble constituents. Gluten proteins are collectively referred to as gliadins and glutenins. Glutenins are polymeric proteins that are linked by disulphide bonds and they improve elasticity and tenacity. Besides, gliadins are monomeric proteins that consist of single chain polypeptides and impart to the viscous properties of dough (Pavlína *et al*., 2011). Gluten also plays a vital role in determining the unique baking quality of wheat due to its water absorption capacity, cohesiveness, viscosity, and elasticity to the dough (Wieser, 2007). Normally, the higher protein contents in flour, higher the gluten formation. When water is added in wheat flour during dough mixing, wheat flour is hydrated and the gluten proteins are transformed into a continuous cohesive viscoelastic gluten protein network. Gluten varies normally in wheat flour ranged from 9.88% to 26.21% (Syeda *et al*., 2012).

2.2.4 Fat

Lipids are present only in a small extent in cereals but they have a significant effect on the quality and the texture of foods because of their ability to associate with proteins due their amphipathic nature and with starch, forming inclusion complexes. In wheat, the maturing seed synthesizes fatty acids at different rates. Kumar *et al*., (2011) analyzed on nutritional contents and medicinal properties of wheat and observed fat present 2.0% in wheat flour, wheat germ contain 9.2% fat and wheat bran contain 5.5% fat. Shahedur Rahman and Abdul Kader, (2011) studied on the comparison of nutritional and physicochemical properties of Bangladeshi wheat verities and observed that fat content of wheat flour was 1.4% average. Baljeet *et al.*, (2010) studied on buckwheat flour for biscuit making and got 1.81% fat in flour.

2.2.5 Vitamin

Vitamins are nutritionally essential micronutrient for humans and function of several ways, including: (1) as coenzymes or their precursors (niacin, thiamin, biotin, pantothenic acid, vitamin B6, vitaminB12 and foliate), (2) in specialized function such as vitamin A in vision and ascorbate in distinct hydroxylation reactions; and (3) as components of the antioxidative defense systems (vitamin C and E and some carotenoids), and as factors involved in human genetic regulation and genomic stability (folic acid, vitamin B12, vitamin B6, niacin, vitamin C, vitamin E and D) (Paredes-López and Osuna–Castro, 2006). The wheat germ, which is removed in the process of refining, is also rich in essential vitamin E. Also small amounts of thiamin riboflavin, niacin, pantothenic acid and pyrimidine are present in wheat flour.

2.2.6 Mineral

Minerals play an important role in maintaining proper function and good health in the human body (Bhat *et al.*, 2010). Approximately 98% of the calcium (Ca) and 80% of the phosphorus (P) in the human body are found in the skeleton. An average adult requires an intake of more than 100 mg per day of macrominerals [Calcium (Ca), phosphorus(P), sodium (Na), potassium (K), magnesium (Mg), chlorine (Cl), and sulphur (S)] and trace elements [selenium (Se), zinc (Zn), copper (Cu), cobalt (Co), manganese (Mn), molybdenum (Mo) and iron (Fe)], with a recommended daily intake within the microgram range to maintain specific functions in the body (Ho *et al.*, 2012). Basically two forms of minerals: macro and trace minerals. Macro means "large" which requires in larger quantity for body needs as compared to trace minerals. The macro mineral includes i.e. calcium, phosphorus, magnesium, sodium, potassium, chloride, and sulfur. However, the human body also requires trace minerals including copper, iron, cobalt, manganese, iodine, zinc and selenium (Shabbir, 2009). Wheat flour consists of 3mg calcium, 0.9mg Iron, 109mg potassium, 6mg sodium, zinc 2.02mg per 100gram reported by Danster *et al*., (2008).

2.2.7 Starch

Cereal grains store energy in the form of starch. The amount of starch contained in a wheat grain may vary between 60% and 75% of the total dry weight of the grain (Belderok *et al*., 2000). Starch is basically a polymer of glucose. Chemically, at least two types of polymers are distinguishable: amylose and amylopectin. Amylose is slightly branched and amylopectin is branched to a much greater extent than amylose. Normal wheat starch typically contains 20–30% amylose and 70–80% amylopectin (Konik-Rose *et al*., 2007). Shahedur Rahman and Abdul Kader, (2011) analyzed on the comparison of nutritional and physicochemical properties of Bangladeshi wheat verities and observed that starch content of wheat flour was 67.50% to 69.50% and reducing sugar was 5.33 mg/gm to 8.60 mg/gm. Oluwamukomi *et al*., (2010) experimented on physicochemical and sensory properties of wheat-cassava composite biscuit enriched with soy flour and determined each composition characteristics and found 68.69% starch in whole wheat flour. Baljeet *et al*., (2010) studied on functional properties and incorporation of buckwheat flour for biscuit making determined the nutritional value and observed that starch was present 75.74% in flour. Masood *et al*., (2004) researched on the effect of moisture on the shelf life of wheat flour and notified that starch was remain 70% in wheat flour and suggested that it effects on the color of the flour. Wheat flours are characterized by the flour extraction rate, which is the proportion of flour by weight, derived by milling from a known quantity of wheat (Slavin *et al*., 2000). According to Ghulam Mueen-ud-din, (2009) carbohydrate percentage depends on the flour extraction rate. If flour extraction rate is increase then carbohydrate percentage decrease such as 100% extraction contain 70.39% starch, 88% extraction contain 71.49% starch,76% extraction contain 72.61% starch and 64% extraction contain 73.81% starch.

2.2.8 Fiber

The beneficial effects of fiber consumption in protection against heart disease and cancer, normalization of blood lipids, regulation of glucose absorption and insulin secretion and prevention of constipation and diverticular disease which was proven by numerous studies (Weickert and Pfeiffer 2007; Rave *et al*., 2008). Dietary fiber is mainly lignin plus the polysaccharide components of plants which are indigestible by enzymes in the human gastrointestinal tract (Zuzana *et al*., 2000). Shahedur Rahman and Abdul Kader, (2011) analyzed on the comparison of nutritional and physicochemical properties of Bangladeshi wheat verities and observed that fiber of wheat flour was 2.1%. Baljeet *et al*., (2010) observed that crude fiber was present 0.70% in flour during biscuit making.

2.3 Varieties of wheat

Various types of wheat are milled into a wide range of flours that are used for specific purposes: Hard wheat varieties, including hard white, hard red winter and hard red spring wheat have a high protein content (ranging from 10 to 14 percent), which means the gluten forming capacity is also higher. This characteristic makes hard wheat flour varieties, (which includes bread flour, gluten flour, and many of the whole-wheat varieties), especially suitable for baking yeast breads and similar products. Soft wheat varieties include soft white and soft red winter, which are both used for products, such as cakes, cookies, and pastries that do not require the same level of leavening capability as yeast breads. The protein content of soft wheat varieties, such as cake and pastry flour, usually ranges from 6 to 10 percent. Durum wheat is the hardest wheat grown. It is used almost exclusively for making pasta and is most often ground into granular flour with a light yellow color known as semolina, which has the ideal properties for making the best pasta. Durum is high in protein and gluten, which are necessary for making good pasta. It is occasionally used for baked goods (especially risen breads), but it is not used for this purpose as often as other wheat varieties.

2.4 Utilization of wheat

2.4.1 Preparation of Bread and Biscuit using wheat flour

Bread is regarded as a staple food and as such attracts regulation of its composition and sometimes price. Asia latif *et al*., (2005) evaluated the properties of bread using wheat flour by adding different additives. Mahmoud Abu-Ghoush *et al*., (2008) reported about effect of preservatives addition on the shelf-life extensions and quality characteristics and shelf life of flat bread. Baljeet *et al*., (2010) analyzed on functional properties and incorporation of buckwheat flour for biscuit making. Ajani *et al*., (2012) evaluation on proximate composition and sensory qualities of snacks produced from breadfruit flour. Wioletta Blaszczak *et al*., (2004) studied the effect of emulsifiers on dough properties and baking quality of biscuits. Sharoba *et al*., (2014) studied about production and evaluation of gluten free biscuits as functional foods for celiac disease patients.

2.4.2 Cake made from wheat flour

Manuel Go´mez *et al*., (2010) reviewed the effects of batter freezing and conditions and resting time before baking on quality of two kinds of cakes (layer and sponge cakes), including freezing temperature (18^{0}C, 26^{0}C), storage time at sub-zero temperatures (30 and 100 days), and resting time (60 and 120 min). Characteristics of the batter (pH, density, viscosity, and microstructure) and cakes (density, texture, and color) were analysed. Freezing process increases batter density and viscosity, and consequently decreases cake volume and height, but increases hardness.

Chunli Jia *et al.*, (2007) investigated the sensory and instrumental (texture and color) quality attributes and their relation of newly formulated Chinese moon cakes. California almond flour and maltitol syrup were used as the replacement of wheat flour and sucrose syrup, respectively and gum was added as the fat-replacer. Sensory analysis showed that addition of almond flour had the most significant ($P \leq 0.05$) effects on the properties of moon cakes, and the 70% replaced moon cake was most favored by the sensory panel and sulphydryl groups resulting in greater loss of solubility. This is attributed to the higher glycation degree and higher carbohydrate content of GCPI as demonstrated by glycoprotein staining of SDS PAGE gels. Water absorption of bread dough was significantly enhanced by DCPI and to a larger extent GCPI compared to the control, resulting in softer texture.

Márcia Arocha Gularte *et al.*, (2012) reported the effect of different fibers, added individually or in combination, to improve the functional properties of gluten-free layer cakes. Soluble (inulin and guar gum), and insoluble (oat fiber) fibers were used to replace up to 20% of rice flour in gluten-free layer cakes formulation. Significantly brighter crust and crumb was obtained in the presence of fibers, excepting the crumb of oat guar gum containing cake. Fibers and its blends increased the crumb hardness; but the smallest effect was observed with the addition of oat, individually or combined with inulin. Enriched cakes increased significantly their dietary fiber content, which was connected to the nature of the fibers added.

Jae Hwan Kim *et al*., (2012) investigate the quality characteristics of sponge cakes made with cheonnyuncho powder. The moisture, ash, and dietary fibre levels in the sponge cakes increased linearly with the addition of 0 to 9 g of cheonnyuncho powder/100 g of wheat flour, and the carbohydrate and calorie contents of the samples decreased.

2.4.3 Cake made with emulsifiers

Paraskevopoulou *et al*., (2014) reported the effect of partial (50 wt %) or total liquid egg i.e. hydroxypropyl methylcellulose (HPMC) and sodium stearoyl-2-lactylate (SSL), on the quality of pound cakes. Complete egg replacement by whey protein isolate (WPI) led to the preparation of cake batter of increased specific gravity as well as to final cake products of inferior quality with regard to volume, texture and hardness increase upon storage, compared to the control. In the case of partial liquid egg replacement by WPI solutions, cakes with acceptable sensory and quality characteristics were obtained, which were further improved following the addition of emulsifiers.

Julia Rodríguez-García *et al*., (2014) studied the functional effects of lipase (0.003 and 0.006 g/100 g of flour) and emulsifier (0.5 and 1 g/100 g of flour) in low fat cakes with inulin (0, 7.5 and 10 g/100g of flour, respectively). Emulsifier addition significantly lowered the relative density of the batter. Emulsifier incorporation increased the viscoelastic properties of the batter. In contrast, lipase incorporation decreased the degree of system structuring.

Sakiyan *et al*., (2004) stated the effects of fat content and emulsifier type on the rheological properties of cake batter. Cake batter with different fat concentrations and emulsifier types exhibited shear thinning and time-independent behavior. The increase in fat content and addition of emulsifier caused a decrease in the apparent viscosity.

Rahmati and Tehrani, (2014) reported the effects of three emulsifiers including distilled glycerol monostearate, lecithin and sorbitan monostearate on eggless cake containing soy milk. Physical properties of cake batters (viscosity, specific gravity and stability), cake quality parameters (moisture loss, density, specific volume, volume index, contour, symmetry, color and texture) and sensory attributes of eggless cakes were analyzed to investigate functional potential of the emulsifiers and results were compared with those of control cake containing egg.

Lakshminarayan *et al*., (2006) studied the effects of maltodextrin and emulsifiers on the viscosity of cake batter and on the quality of cakes. The viscosity of batter was reduced significantly when fat was replaced with equal quantities of maltodextrin.

CHAPTER III

MATERIALS AND METHODS

CHAPTER III

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3.1 Ingredients

Wheat flour, sugar, baking powder, fresh eggs were purchased from the local market. Commercially available food grade ester of monoglyceride, glycerol monostearate, disodium phosphate, guar gum, sorbitol, glycerol, propylene glycol, sodium benzoate, potassium sorbate were purchased from Dhaka.

3.2 Cake formulation and preparation

Cakes formulations are given in Table 3.1.Wheat flour and other ingredients for each cake were weighed accurately. Egg white and sugar were poured into a bowl and mixed by a mixing machine (NM-76, China) for ten minutes to produce a cream. Then various emulsifiers (ester of monoglyceride, glycerol monostearate and di sodium phosphate) and additives (sorbitol, glycerol, propylene glycol, baking powder, sodium benzoate and potassium sorbate) were added. Finally egg yolk, wheat flour and oil were poured into the mixer and mixed by mixing machine for ten minutes to ensure proper distribution of the all components. The bowl was scrapped and batter was mixed for an additional two minutes. The cake batter was put into pre-greased cake pan. All cakes were baked in electric oven (JS-918, China) for twenty minutes at 180°C. The cakes were allowed to cool for one hour and then removed from the pans. The cooled cakes were packed in polypropylene bags and stored at room temperature for further uses.

Table 3.1 Formulations of the different cakes (quantities are given in flour basis: g/50 g of flour)

Ingredients	Cake 1	Cake 2	Cake 3	Cake 4	control
Wheat flour	50	50	50	50	50
Sugar	60	60	60	60	60
Egg	60	60	60	60	60
Sodium bi carbonate	2	2	2	2	2
Citric acid	1	1	1	1	1
Ester of monoglyceride	1.5	1.5	1.5	-	-
Glycerol monosterate	0.2	0.2	-	0.2	-
Di sodium phosphate	0.35	-	0.35	0.35	-
Sorbitol	2	2	2	2	2
Glycerol	1.2	1.2	1.2	1.2	1.2
Propylene glycol	0.07	0.07	0.07	0.07	0.07
Sodium benzoate	0.05	0.05	0.05	0.05	-
Potassium sorbate	0.05	0.05	0.05	0.05	-

3.3 Physical characteristics of cake dough

The specific gravity of each type of cake dough was determined dividing the weight of cake dough by the weight of water. The dough yield of each type of cake were measured the loss of cake weight after baking. Specific gravity and dough yield were calculated by following formula:

$$\text{Specific gravity (ml/g)} = \frac{\text{Volume of dough}}{\text{weight of cake}} \times 100$$

$$\text{Dough yield (g/100g)} = \frac{\text{weight of cake}}{\text{weight of dough}} \times 100$$

3.4 Proximate composition of cake

3.4.1 Determination of moisture content

AOAC method 7.045(2005) was used to determine the moisture content of cake. Cake (3g) was taken in a clean, dry and pre-weighted crucible. Then the cake was transferred to oven and dried at 105ºC for 24 hours. After that it was cooled at desiccator and weighed. Moisture Content was calculated by following formula:

$$\% \text{ Moisture} = (W_1 - W_2)/w \times 100$$

Here,

W_1 = weight of sample with crucible

W_2= weight of dried sample with crucible

w = weight of sample

3.4.2 Determination of protein

Protein content in the sample was measured spectrophotometrically according to Bradford method (Bradford MM, 1976) with little modification. Sample (1g) was taken in a beaker then 10 mL of distilled water was added to it. Then the sample was stirred with magnetic stirrer. After that filtration was done with a filter paper. Then 500µL sample (after filtration) was taken into a falcon tube and diluted to 5mL distilled water. Then 5mL of Bradford reagent was added and mixed by vortex (KMC-1300V, Korea) for few minutes. The concentration of protein in the solution was determined from the absorbance at 595 nm (T60 U, PG instrument, United Kingdom). Protein content was calculated on the basis of calibration curves of bovine serum albumin and expressed as percentage.

3.4.3 Determination of fat

AOAC method 7.045(2000) was used with some modification to determine the fat content of the Cake. Cake (3g) was taken into the thimble. The thimble was attached to the Soxhlet apparatus which was attached with a round bottom flask containing 200 ml petroleum ether. The fat was extracted for 6 hours. After that petroleum ether was evaporated at 80ºC until the flask completely dried. Fat content was calculated by following formula:

$$\% \text{ Fat} = (W_1-W_2)/w \times 100$$

Here,

W_1= weight of evaporated flask with fat

W_2= weight of empty flask

w= weight of sample

3.4.4 Determination of total ash

AOAC method 14.006(2000) was used to determine the total ash content. Cake (3g) was weighed and transferred into a clean, dry and pre-weighted crucible. Then the crucible was kept into muffle furnace at 550ºC for 5.5 hours. It was cooled at desiccator and weighed. The ash content was calculated by the following formula:

$$\% \text{ Ash} = (W_1-W_2)/w \times 100$$

Here,

W_1= weight of ash with crucible

W_2 = weight of empty crucible

w= weight of sample

3.5 Determinations of color

The color attributes (L^*, a^* and b^* values) of the cake samples from the crust of the cakes were measured using a color measurement spectrophotometer (Minolta Camera, Tokyo, Japan).

3.6 Firmness of cake

Firmness was measured with penetrometer (Gy-4, china). An 8 mm diameter cylindrical probe was penetrated into cake surface at a 1mms^{-1} speed. After that automatic data was shown on penetrometer screen. Data was expressed as kg/min.

3.7 Sensory evaluation

Consumer acceptance test were performed by hedonic test (9 point scale) for the cake at 0 and 30th day. Ten panelists were selected from university those are familiar with cake. Panelists were facilitated to rinse their mouth with tap water in between evaluation. The samples were placed in white plate and were identified with random three digit numbers. Sensory characteristics were color, flavor, texture, taste and overall acceptability.

3.8 Statistical Analysis

Each experiment was done in duplicate. The results were expressed as mean ± standard deviation and were analyzed by R software (version 2.13.1). Significant differences between the means were determined by Duncan's Multiple Range test. $P \leq 0.05$ was considered as a level of significance.

CHAPTER IV

RESULTS AND DISCUSSION

CHAPTER IV

RESULTS AND DISCUSSION

4.1 Proximate composition of cake during storage

Proximate compositions of cake prepared with various emulsifiers during storage are shown in Table 4.1. Moisture, protein, fat, ash and carbohydrate content of ranged from 10.36% to 16.04%, 6.40% to 13.62%, 22.16% to 33.76%, 0.49% to 1.15% and 42.79% to 58.98% respectively. Control cake without emulsifiers had lower moisture, fat and ash content than cake prepared with various emulsifiers at zero days. Emulsifiers stimulated the incorporation of air as well as enhancing the aeration capacity into cake (Rodríguez-García *et al*., 2014). Fat and ash content increased due to use of additional emulsifiers. Seyhun *et al*., (2003) who found higher moisture content using purawave and diacetyl tartaric esters of monoglycerides in cakes. Sowmya *et al*., (2009) revealed that cake prepared with emulsifiers glycerol monostearate and sodium stearoyl-2-lactylate (GMS and SSL) had higher moisture content than cake prepared without emulsifiers. Moisture and fat contents were increased for all samples except cake made with ester of monoglyceride, glycerol monostearate and di sodium phosphate whereas protein increased and ash content was decreased for all samples after 30th days of storage. Protein, ash and fat content influenced might be attributed to the interaction with emulsifiers, wheat protein and other constituents throughout storage period.

Table 4.1 Effects of various types of emulsifiers on proximate composition of cake during storage

Composition (%)	Storage (days)	Cake 1	Cake2	Cake3	Cake 4	Control
Moisture	0	^{A}16.00 ± 3.08^{a}	^{A}12.96± 1.52^{ab}	^{B}13.01± 0.24^{ab}	^{B}13.14 ±0.23^{ab}	^{B}10.36± 0.05^{b}
	15	^{A}16.04± 2.41^{a}	^{A}14.81± 1.51^{a}	^{A}13.83± 0.19^{a}	^{A}15.40± 1.10^{a}	^{A}12.48 ±0.28^{a}
	30	^{A}14.63 ±2.38^{a}	^{A}14.08± 0.79^{a}	^{A}13.81± 0.05^{a}	^{AB}15.01 ±0.38^{a}	Not acceptable
Protein	0	^{C}7.55±0.35^{a}	^{B}6.40±0.61^{b}	^{A}6.92±0.15^{ab}	^{B}7.60±0.23^{a}	^{A}7.85±0.24^{a}
	15	^{B}11.59±0.27^{a}	^{A}11.25±0.51^{a}	^{A}10.44 ±2.24^{a}	^{A}12.36±0.33^{a}	^{A}10.47±1.94^{a}
	30	^{A}13.62± 0.75^{a}	^{A}12.53± 0.40^{a}	^{A}11.90± 1.98^{a}	^{A}12.17 ±1.47^{a}	Not acceptable
Fat	0	^{A}24.86±0.197^{a}	^{A}24.63±0.52^{a}	^{A}24.65±0.32^{a}	^{A}22.35±0.256^{a}	^{A}22.16±7.82^{a}
	15	^{A}23.91 ±1.03^{b}	^{A}26.02±1.14^{ab}	^{A}26.10±1.57^{ab}	^{A}23.85±3.981^{b}	^{A}33.76± 6.11^{a}
	30	^{A}23.70 ±0.84^{a}	^{A}27.08± 1.32^{a}	^{A}25.56± 3.44^{a}	^{A}24.57± 1.36^{a}	Not acceptable
Ash	0	^{A}1.03±0.01^{a}	^{A}1.03±0.076^{a}	^{A}1.08±0.005^{a}	^{A}1.02±0.03^{a}	^{A}0.65±0.15^{b}
	15	^{A}1.15±0.171^{a}	^{A}1.09±0.120^{a}	^{A}1.11±0.098^{a}	^{A}1.03±0.103^{a}	^{A}0.49±0.026^{b}
	30	^{A}0.92 ±0.12^{a}	^{A}0.94± 0.08^{a}	^{A}0.95±0.09^{a}	^{A}0.99± 0.02^{a}	Not acceptable
Carbohydrate	0	^{A}50.54 ±3.24^{a}	^{A}54.98± 0.31^{a}	^{A}54.34± 0.58^{a}	^{A}55.88 ±1.18^{a}	^{A}58.98± 7.86^{a}
	15	^{A}45.80± 0.63^{a}	^{B}46.82± 1.21^{a}	^{A}48.50± 4.1^{a}	^{B}47.34 ±2.65^{a}	^{A}42.79± 4.47^{a}
	30	^{A}47.11± 3.85^{a}	^{B}45.35 ±1.01^{a}	^{A}47.76± 5.57^{a}	^{B}47.24± 2.48^{a}	Not acceptable

Cake 1, cake 2, cake 3, cake 4 and control cake abbreviations are given in Table 3.1

$^{a\text{-}b}$ Means followed by different superscript in each row are significantly different among cakes at $p \leq 0.05$

$^{A\text{-}B}$ Means followed by different superscript in each column are significantly different among storage time at $p \leq 0.05$

4. 2 Physical attributes of cake

The specific gravity and dough yield of cakes are shown in Table 4.2. Low specific gravity implies that more air is incorporated into cake (Turabi *et al*., 2008). Cake prepared with ester of monoglyceride, glycerol monostearate and di sodium phosphate had lower specific gravity as compared to other cake. Control cake showed higher specific gravity than cakes prepared with emulsifiers. Mixing condition, amount of egg white, baking powder and water vaporization during baking could be influenced specific gravity in cake (Rahmati and Tehrani, 2014).

Moisture, air and CO_2 might be influenced of dough yield. Cake prepared with glycerol monostearate and di sodium phosphate had higher dough yield whereas cake prepared with ester of monoglyceride and di sodium phosphate had lower dough yield. This could be due to different emulsifiers hold different amount of CO_2 and air during storage (Rahmati and Tehrani, 2014).

4.3 Firmness of cake during storage

The firmness of cake ranges from 0.25 to 0.74 kg/min (see Table 4.3). Cake prepared with di sodium phosphate and glycerol monostearate had higher firmness than other cakes at zero days. Cake prepared without emulsifiers had lower firmness than cake prepared with emulsifiers such as glycerol monostearate and di sodium phosphate. On the other hand cake prepared with ester of monoglyceride and glycerol monostearate had lower firmness as compared to other cakes at zero days. Firmness increased with increased storage time for all samples. Firmness depends on transfer of water from moist to dry zone into cake. Another one is starch retrogradation (Zhou *et al*., 2011). Emulsifiers have been used as a softening (anti-staling) agent and are able to form complexes with the starch which slows down the retrogradation process in the baked product during storage (Cauvin and Young 2006).

Table 4.2 Effects of various types of emulsifiers on physical attributes of cake

Properties	Cake1	Cake2	Cake3	Cake4	Control
Specific gravity (ml/g)	1.43 ± 0.00^{c}	1.55 ± 0.06^{ab}	1.52 ± 0.04^{bc}	1.51 ± 0.00^{bc}	1.65 ± 0.007^{a}
Dough yield (g/100g)	90.22 ± 0.63^{b}	91.26 ± 0.43^{ab}	90.11 ± 0.90^{b}	92.39 ± 0.37^{a}	90.91 ± 0.05^{b}

Cake 1, cake 2, cake 3, cake 4 and control cake abbreviations are given in Table 3.1
$^{a-b}$ Means followed by different superscript in each row are significantly different among cakes at $p\leq 0.05$

Table 4.3 Effects of various types of emulsifiers on firmness of cake during storage

Properties	Storage (days)	Cake1	Cake2	Cake3	Cake4	Control
	0	$^{A}0.27\pm 0.01^{a}$	$^{A}0.25 \pm 0.06^{a}$	$^{A}0.27\pm 0.09^{a}$	$^{A}0.38\pm 0.25^{a}$	$^{A}0.35\pm 0.05^{a}$
Firmness(kg/min)	15	$^{A}0.43\pm 0.03^{a}$	$^{A}0.49\pm 0.07^{a}$	$^{A}0.52\pm 0.15^{a}$	$^{A}0.49\pm 0.26^{a}$	$^{A}0.74\pm 0.24^{a}$
	30	$^{A}0.42\pm 0.13^{a}$	$^{A}0.43\pm 0.11^{a}$	$^{A}0.49\pm 0.18^{a}$	$^{A}0.49\pm 0.39^{a}$	Not acceptable

Cake 1, cake 2, cake 3, cake 4 and control cake abbreviations are given in Table 3.1
a-b Means followed by different superscript in each row are significantly different among cakes at $p\leq 0.05$
A-B Means followed by different superscript in each column are significantly different among storage time at $p\leq 0.05$

4.4 Color attributes of cake during storage

The color attributes of cakes are shown in Table 4.4. Control sample had higher lightness and lower redness and yellowness than cake prepared with various emulsifiers at zero days. It might be browning reaction more occurred in cake prepared with emulsifiers during baking. On the other hand L^* values were decreased whereas a^* and b^* values were increased for all sample after 30^{th} days of storage. This might be interaction between emulsifiers and amylose. There was no significant differences in L^*, a^* and b^* values among various cake made with different emulsifiers.

Table 4.4 Effects of various types of emulsifiers on color attributes of cake during storage

Crust color	Storage (days)	Cake1	Cake2	Cake3	Cake4	Control
	0	$^{A}43.36\pm6.13^{a}$	$^{A}48.18\pm1.53^{a}$	$^{A}47.57\pm7.58^{a}$	$^{A}50.30\pm0.89^{a}$	$^{A}56.81\pm8.38^{a}$
L^{*}	15	$^{A}53.09\pm3.31^{a}$	$^{A}56.41\pm7.05^{a}$	$^{A}53.23\pm0.60^{a}$	$^{A}47.49\pm10.57^{a}$	$^{A}57.14\pm2.91^{a}$
	30	$^{A}42.73\pm0.03^{a}$	$^{A}48.17\pm4.73^{a}$	$^{A}41.75\pm7.91^{a}$	$^{A}40.65\pm7.51^{a}$	Not acceptable
	0	$^{A}10.31\pm6.66^{a}$	$^{A}8.38\pm12.75^{a}$	$^{A}11.52\pm11.05^{a}$	$^{A}8.86\pm8.35^{a}$	$^{A}6.47\pm8.66^{a}$
a^{*}	15	$^{A}16.15\pm2.18^{a}$	$^{A}15.05\pm1.97^{a}$	$^{A}15.36\pm1.45^{a}$	$^{A}18.49\pm0.25^{a}$	$^{A}14.97\pm0.66^{a}$
	30	$^{A}15.65\pm0.62^{ab}$	$^{A}16.97\pm0.29^{ab}$	$^{A}14.72\pm2.27^{b}$	$^{A}18.17\pm0.17^{a}$	Not acceptable
	0	$^{A}31.51\pm2.81^{a}$	$^{B}31.41\pm1.13^{a}$	$^{A}32.57\pm7.33^{a}$	$^{A}33.92\pm1.45^{a}$	$^{A}31.93\pm5.99^{a}$
b^{*}	15	$^{A}39.78\pm2.24^{a}$	$^{A}38.50\pm1.33^{a}$	$^{A}38.15\pm0.32^{a}$	$^{A}34.47\pm10.28^{a}$	$^{A}34.70\pm0.38^{a}$
	30	$^{A}32.17\pm2.96^{a}$	$^{AB}36.54\pm2.29^{a}$	$^{A}33.88\pm3.79^{a}$	$^{A}31.59\pm7.68^{a}$	Not acceptable

Cake 1, cake 2, cake 3, cake 4 and control cake abbreviations are given in Table 3.1

$^{a\text{-}b}$ Means followed by different superscript in each row are significantly different among cakes at $p\leq0.05$

$^{A\text{-}B}$ Means followed by different superscript in each column are significantly different among storage time at $p\leq0.05$

4.5 Sensory attributes of cake during storage

Various emulsifier impacts on sensory attributes of cakes are shown in Table 4.5. The sensory profile of the cakes were evaluated in terms of color, flavor, texture, taste and overall acceptability at 0 and 30^{th} days of storage. Color was similar for all samples at zero days. However, color was decreased after 30^{th} days of storage for all samples. This is mainly due to decrease in lightness. Cake prepared with ester of monoglyceride and di sodium phosphate had highest flavor and taste scores as compared to others cake. Flavor and taste might be depended on emulsifier's type. Texture scores were not related to firmness. Cake prepared with glycerol monostearate and di sodium phosphate had highest texture and overall acceptability scores than other cake. However, there was no significant difference in overall acceptability among all cakes prepared with emulsifiers.

Table 4.5 Effects of various types of emulsifiers on sensory attributes of cake during storage

Sensory characteristics	Storage (days)	Cake 1	Cake 2	Cake 3	Cake 4	Control
Color	0	$^{A}8.27 \pm 0.23^{a}$	$^{A}8.05 \pm 0.07^{a}$	$^{A}8.00 \pm 0.00^{a}$	$^{A}8.10 \pm 0.00^{a}$	8.1 ± 0.14^{a}
	30	$^{A}8.00 \pm 0.14^{ab}$	$^{A}7.75 \pm 0.07^{b}$	$^{A}7.90 \pm 0.14^{ab}$	$^{A}8.20 \pm 0.14^{a}$	Not acceptable
Flavor	0	$^{A}7.60 \pm 0.00^{a}$	$^{A}7.55 \pm 0.07^{a}$	$^{A}7.70 \pm 0.28^{a}$	$^{A}7.65 \pm 0.21^{a}$	7.75 ± 0.07^{a}
	30	$^{A}7.75 \pm 0.21^{a}$	$^{A}7.65 \pm 0.21^{a}$	$^{A}8.10 \pm 0.00^{a}$	$^{A}8.00 \pm 0.00^{a}$	Not acceptable
Texture	0	$^{A}7.95 \pm 0.21^{a}$	$^{A}7.80 \pm 0.00^{a}$	$^{A}7.75 \pm 0.07^{a}$	$^{A}7.30 \pm 0.28^{b}$	7.75 ± 0.07^{a}
	30	$^{A}7.75 \pm 0.07^{a}$	$^{A}7.95 \pm 0.35^{a}$	$^{A}7.85 \pm 0.07^{a}$	$^{A}8.00 \pm 0.28^{a}$	Not acceptable
Taste	0	$^{A}7.70 \pm 0.42^{a}$	$^{A}7.85 \pm 0.21^{a}$	$^{B}7.86 \pm 0.06^{a}$	$^{A}7.85 \pm 0.07^{a}$	7.70 ± 0.14^{a}
	30	$^{A}7.70 \pm 0.28^{b}$	$^{A}7.9 \pm 0.00^{ab}$	$^{A}8.35 \pm 0.07^{a}$	$^{A}8.15 \pm 0.15^{ab}$	Not acceptable
Overall acceptability	0	$^{A}7.95 \pm 0.21^{a}$	$^{A}7.80 \pm 0.14^{a}$	$^{A}7.70 \pm 0.14^{a}$	$^{B}7.70 \pm 0.00^{a}$	7.75 ± 0.21^{a}
	30	$^{A}7.90 \pm 0.28^{a}$	$^{A}7.75 \pm 0.21^{a}$	$^{A}8.05 \pm 0.07^{a}$	$^{A}8.15 \pm 0.07^{a}$	Not acceptable

Cake 1, cake 2, cake 3, cake 4 and control cake abbreviations are given in Table 3.1

$^{a-b}$ Means followed by different superscript in each row are significantly different among cakes at $p \leq 0.05$

$^{A-B}$ Means followed by different superscript in each column are significantly different among storage time at $p \leq 0.05$

CHAPTER V

CONCLUSION

CHAPTER V

CONCLUSION

Three emulsifiers were used to prepare cake and impacts of emulsifiers on nutritional quality of cake during storage were investigated. There were significant differences in protein content throughout storage period for cake prepared with ester of monoglyceride, glycerol monostearate and di sodium phosphate. There was no significant differences in L^*, a^*, b^* values and overall acceptability among various cake made with different emulsifiers. As a result a good quality cake made with the ester of monoglyceride, glycerol monostearate and di sodium phosphate that would be more attractive for consumers especially for children.

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APPENDICES

APPENDICES

Appendix I

Effects of various types of emulsifiers on proximate composition of cake at 0 days

Compositions (%)	Cake 1	Cake 2	Cake 3	Cake 4	Control
Moisture	13.82	11.88	13.18	12.98	10.31
	18.18	14.04	12.84	13.3	10.4
Ash	1.04	1.08	1.08	1	0.54
	1.024	0.972	1.088	1.04	0.75
Protein	7.3	6.84	6.81	7.77	8.02
	7.83	5.97	7.02	7.44	7.68
Fat	25	25	25	23.2	27.7
	24.75	24.26	24.3	21.72	16.63
Carbohydrate	52.84	55.2	53.93	55.05	53.42
	48.25	54.758	54.752	56.72	64.54

Appendix II

Effects of various types of emulsifiers on proximate composition of cake at 15 days

Compositions (%)	Cake 1	Cake 2	Cake 3	Cake 4	Control
Moisture	14.33	13.74	13.97	14.62	12.28
	17.75	15.88	13.7	16.18	12.68
Ash	1.278	1.18	1.18	1.11	0.472
	1.036	1.01	1.04	0.964	0.51
Protein	11.4	11.61	12.03	12.13	11.85
	11.79	10.89	8.86	12.6	9.1
Fat	24.64	25.79	27.22	26.67	29.44
	23.17	26.25	24.99	21.04	38.08
Carbohydrate	45.352	47.68	45.6	45.47	45.96
	46.25	45.97	51.41	49.22	39.63

Appendix III

Effects of various types of emulsifiers on proximate composition of cake at 30 days

Compositions (%)	Cake 1	Cake 2	Cake 3	Cake 4	Control
Moisture	12.95	13.52	13.85	14.74	Not acceptable
	16.32	14.65	13.78	15.29	Not acceptable
Ash	1.006	0.998	1.02	1.004	Not acceptable
	0.838	0.882	0.89	0.97	Not acceptable
Protein	13.09	12.82	13.31	13.22	Not acceptable
	14.15	12.25	10.5	11.13	Not acceptable
Fat	23.11	28.02	28	25.54	Not acceptable
	24.3	26.15	23.13	23.61	Not acceptable
Carbohydrate	49.84	44.64	43.82	45.49	Not acceptable
	44.39	46.07	51.7	49	Not acceptable

Appendix IV

Effects of various types of emulsifiers on color attributes of cake at 0 days

Crust color	Cake 1	Cake 2	Cake 3	Cake 4	Control
L^*	39.02	49.27	42.21	50.93	50.88
	47.7	47.1	52.93	49.67	62.74
a^*	5.6	-0.64	3.69	2.95	0.34
	15.03	17.4	19.35	14.77	12.6
b^*	29.52	30.61	27.19	32.89	27.69
	33.5	32.22	37.56	34.95	36.17

Appendix V

Effects of various types of emulsifiers on color attributes of cake at 15 days

Crust color	Cake 1	Cake 2	Cake 3	Cake 4	Control
L^*	55.44	61.4	53.66	54.97	55.08
	50.75	51.42	52.81	40.01	59.2
a^*	14.61	13.66	14.33	18.31	14.5
	17.7	16.45	16.39	18.67	15.44
b^*	41.37	39.44	37.93	41.47	34.98
	38.2	37.56	38.38	27.2	34.43

Appendix VI

Effects of various types of emulsifiers on color attributes of cake at 30 days

Crust color	Cake 1	Cake 2	Cake 3	Cake 4	Control
L^*	42.71	51.52	36.16	45.96	Not acceptable
	42.75	44.83	47.35	35.34	Not acceptable
a^*	16.09	17.18	13.11	18.29	Not acceptable
	15.21	16.76	16.33	18.05	Not acceptable
b^*	34.27	38.17	31.2	37.02	Not acceptable
	3.08	34.92	36.57	26.16	Not acceptable

Appendix VII

Effects of various types of emulsifiers on sensory attributes of cake at 0 days

Sensory attributes	Cake 1	Cake 2	Cake 3	Cake 4	Control
Color	8.1	8.1	8	7	8.2
	8.4	8	8	8	8
Flavor	7.6	7.6	7.9	7.8	7.8
	7.6	7.5	7.5	7.5	7.7
Texture	8.1	7.8	7.7	7.1	7.8
	7.8	7.8	7.8	7.5	7.7
Taste	8	8	7.8	7.9	7.6
	7.4	7.7	7.9	7.8	7.8
Overall acceptability	7.8	7.9	7.8	7.7	7.9
	8.1	7.7	7.6	7.7	7.6

Appendix VIII

Effects of various types of emulsifiers on sensory attributes of cake at 30 days

Sensory attributes	Cake 1	Cake 2	Cake 3	Cake 4	Control
Color	8.1	7.7	8	8.3	Not acceptable
	7.9	7.8	7.8	8.1	Not acceptable
Flavor	7.9	7.5	8.1	8	Not acceptable
	7.6	7.8	8.1	8	Not acceptable
Texture	7.8	7.7	7.8	7.8	Not acceptable
	7.7	8.2	7.9	8.2	Not acceptable
Taste	7.9	7.9	8.3	8	Not acceptable
	7.5	7.9	8.4	8.3	Not acceptable
Overall acceptability	8.1	7.6	8.1	8.1	Not acceptable
	7.7	7.9	8	8.2	Not acceptable

Appendix IX

Effects of various types of emulsifiers on firmness of cake during storage

Firmness	Cake 1	Cake 2	Cake 3	Cake 4	Control
0	0.26	0.3	0.2	0.56	0.39
	0.28	0.21	0.34	0.2	0.31
15	0.45	0.54	0.42	0.68	0.91
	0.41	0.44	0.63	0.3	0.57
30	0.33	0.51	0.62	0.77	Not acceptable
	0.52	0.35	0.37	0.22	Not acceptable

Appendix X

Effects of various types of emulsifiers on physical attributes of cake

Physical attributes	Cake 1	Cake 2	Cake 3	Cake 4	Control
Specific gravity	1.43	1.51	1.54	1.51	1.66
	1.43	1.6	1.51	1.51	1.65
Dough yield	89.78	90.96	90.55	92.13	90.96
	90.67	91.57	89.67	92.65	90.86