Optimization of levels of Baking ingredients for development of Sugar free Cake, using Sucrolase

THESIS

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By

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2012

CERTIFICATE - I

This is to certify that the thesis entitled, **"Optimization of levels of baking ingredients for development of sugar free cake, using sucrolase"** Submitted in partial fulfillment of the requirement for the degree of **"MASTER OF SCIENCE"** in Agriculture Food Science & Technology, Jawaharlal Nehru Krishi Vishwa Vidyalaya, Jabalpur is a record of the bonafide research work carried out by **KRISHN PAL BAGRI** under my guidance and supervision. The Student's Advisory Committee and the Director of Instruction have approved the subject of the thesis.

No part of the thesis has been submitted for any other degree or diploma (Certificate awarded etc.) or has been published/published part has been fully acknowledged. All the assistance and help received during the course of investigation have been duly acknowledged by him.

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CERTIFICATE - II

This is to certify that the thesis entitled, **"Optimization of levels of baking ingredients for development of sugar free cake, using sucrolase"** submitted by **KRISHN PAL BAGRI** to the Jawaharlal Nehru Krishi Vishwa Vidyalaya, Jabalpur in partial fulfilment of the requirements for the degree of **"MASTER OF SCIENCE IN AGRICULTURE"** in the Department of **Food science and technology,** JNKVV, Jabalpur has been, after evaluation, approved by the External Examiner and by the Student's Advisory Committee after an oral Examination on the same.

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Place: Jabalpur

Date:..... **(KRISHN PAL BAGRI)**

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ABBREVATION

mm	**=**	**Millimeter**
ml	**=**	**Milliliter**
g	**=**	**Gram**
No.	**=**	**Number**
i.e	**=**	**That is**
^{0}C	**=**	**Degree Celsius**
etc	**=**	**et cetra**
et al	**=**	**Co- worker**
D	**=**	**Dimeter**
T	**=**	**Thickness**
Vol.	**=**	**Volume**
W	**=**	**Weight**
C	**=**	**Colour**
G	**=**	**Grain**
T	**=**	**Texture**
F	**=**	**Flaour**
TC	**=**	**Total score**
%	**=**	**Percent**
Viz.	**=**	**Namely**

VITA

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For the partial fulfillment of Master's Degree he was assigned a research problem entitled ***"Optimization of levels of Baking ingredients for development of sugar free Cake, using sucrolase"***

INTRODUCTION

In this era of industrialization and technological advancement, the life style of the people has changed. With the changing lifestyle, demand for ready to eat and convenient foods has increased considerably. Different types of such products are available in market. Among these, bakery products are very common in children and adults.

Indian industrial scenario indicates that Bakery may be considered as the largest industry among other food based industries in India with an annual turnover of Rs.7500 crores (Kamaliya and Subhash, 2003). The present growth rate of bakery industry is around 12% per annum. Bakery products are increasingly becoming popular in India as indicated by over 2.5 fold increase in their production during the last two decades (Puranik, 2003). India produces 3 million tones of bakery products particularly bread, biscuits and cakes (Samanth, 2002).

The bakery units are unevenly spread among States. These are mainly concentrated in the States of Maharashtra, West Bengal, Andhra Pradesh, Karnataka and Uttar Pradesh. Industrially advanced States like Maharashtra and West Bengal have very Large number of bakery units. The per capita consumption is very high in industrialized States like Maharashtra and West Bengal. Among bakery products Cake are very important.

Cakes are most popular and widely consumed bakery food in India. They are among the low cost processed food in the country when compared to Indian sweet meats. Cake is often the dessert of choice for meals at ceremonial occasions, particularly weddings, anniversaries, and birthdays. Cake offers good nutrition and taste; they can be packed in a variety of size. They have relatively longer self life then other snack food and can be used with advantage for fortification purpose. There are countless cake recipes; some are bread-like, some rich and elaborate, and many are centuries old. With changing food needs and socio economic pattern, they are no longer a tea time snack but have become an essential item in an average Indian house hold.

The raw materials for production of cake are refined wheat flour, sugar, shortening, milk solids, leavening agents and emulsifier (Kamaliya abd kamaliya 2001). The baker formula of cake contain wheat flour 100% sugar 100% fat 50 % baking powder, milk solids/egg, dry fruits and flavoring substance. The high sugar and fat content of cake increases the total calorie of product, over consumption may contribute to high risk of health problems such as coronary diseases, high blood pressure and cholesterol diabetes, obesity and some cancers (Knecht, 1990; Newsome, 1993). The replacement of sucrose by using sugar substitutes (Sucrolase xylitol, sorbitol, acesulfame-K, aspartame, saccharin) in Cake has not been investigated. Thus it is important to find an alternative sugar substitute to traditional sugars in order to improve the quality of cake. The previous study in my laboratory showed that sucrolase can be used as sugar substitute in biscuit formulation, that has arose the possibilities also in cake and other bakery products.

Sucrolase a non sugar sweetener provides about 600 times of sucrose sweetness with no unpleasant residual flavour, non- caloric, non- cariogenic and proven as safe for human consumption (Wallis, 1993). The utilization of low-calorie sweeteners has been increased, which promote a better quality of low-calorie bakery products (Akesowan, 2009). The replacement of sucrose using sugar substitutes and other baking ingredients such as shortening, skimmed milk powder, and baking powder may cause deviation in physical properties and sensory quality attributes of cakes that are to be optimized. The information on above aspect is quite merge which requires systematic investigation.

In the optimization of level of different ingredients, normally in a simple experimental design are used, variation in one ingredient is studied at one time. After optimization of its level, another ingredient is varied for improvement in product quality. This technique makes it difficult to study the effect of several ingredients at one time. Even if it is possible, number of experiments become too large, further it is very difficult to predict relative contribution of individual ingredient on product characteristics. Response Surface Methodology is a latest statistical technique which can be used to study the effect of various ingredients at one time on product quality. The design in general selects broad level of different ingredients for

optimization of formulation. In order to provide nutritious, low calorie, low cost cake the present investigation entitled “Optimization of levels of baking ingredients for development of sugar free cake using sucrolase” has been planed in central composite rotatable design and Response surface methodology, with following objectives:

1. To study physical properties and sensory characteristics of Cake, using different levels of sucrolose (sugar free) and baking ingredients in the formulation.
2. To optimize level of different ingredients of Cake, using response surface methodology (RSM) technique.
3. To develop the models for various significant physical and sensory characteristics of Cake.

REVIEW OF LITERATURE

This chapter is intended to review the published research work done on, cake variety of cake, cake ingredients, their effect on cake properties, sugar substitutes, sucralose its uses in food products. The available literature has been summarized and presented as under.

2.1 Cake

Cake is a form of bread or bread-like food. In its modern forms, it is typically a sweet and enriched baked dessert. In its oldest forms, cakes were normally fried breads or cheesecakes, and normally had a disk shape. Determining whether a given food should be classified as bread, cake, or pastry can be difficult.

Modern cake, especially layer cakes, normally contain a combination of flour, sugar, eggs, and butter or oil, with some varieties also requiring liquid (typically milk or water) and leavening agents (such as yeast or baking powder). Flavorful ingredients like fruit purées, nuts, dried or candied fruit, or extracts are often added, and numerous substitutions for the primary ingredients are possible. Cakes are often filled with fruit preserves or dessert sauces (like pastry cream), iced with butter cream or other icings, and decorated with marzipan, piped borders or candied fruit. Cake is often the dessert of choice for meals at ceremonial occasions, particularly weddings, anniversaries, and birthdays. There are countless cake recipes; some are bread-like, some rich and elaborate, and many are centuries old. Cake making is no longer a complicated procedure; while at one time considerable labor went into cake making (particularly the whisking of egg foams), baking

equipment and directions have been simplified that even the most amateur cook may bake a cake.

2.2 Varieties of Cake

Cakes are broadly divided into several categories, based primarily on ingredients and cooking techniques.

1. **Yeast cakes** are the oldest and are very similar to yeast breads. Such cakes are often very traditional in form, and include such pastries as babka and stollen.
2. **Cheesecakes**, despite their name, aren't really cakes at all. Cheesecakes are in fact custard pies, with a filling made mostly of some form of cheese (often cream cheese, mascarpone, ricotta or the like), and have very little flour added, although a flour-based or graham cracker crust may be used. Cheesecakes are also very old, with evidence of honey-sweetened cakes dating back to ancient Greece.
3. **Sponge cakes** are thought to be the first of the non-yeast-based cakes and rely primarily on trapped air in a protein matrix (generally of beaten eggs) to provide leavening, sometimes with a bit of baking powder or other chemical leaven added as insurance. Such cakes include the Italian/Jewish *pan di Spagna* and the French Génoise. Highly decorated sponge cakes with lavish toppings are sometimes called *gateau*; the French word for cake.
4. **Butter cakes**, including the pound cake and devil's food cake, rely on the combination of butter, eggs, and sometimes baking powder or bicarbonate of soda to provide both lift and a moist texture.

A large cake garnished with strawberries Beyond these classifications, cakes can be classified based on their appropriate accompaniment (such as coffee cake) and contents (e.g. fruitcake or flourless chocolate cake).Some varieties of

cake are widely available in the form of cake mixes, wherein some of the ingredients (usually flour, sugar, flavoring, baking powder, and sometimes some form of fat) are premixed, and the cook needs add only a few extra ingredients, usually eggs, water, and sometimes vegetable oil or butter. While the diversity of represented styles is limited, cake mixes do provide an easy and readily available homemade option for cooks who are not accomplished bakers.

2.3 Special-purpose cakes

Cakes may be classified according to the occasion for which they are intended. For example, wedding cakes, birthday cakes, Christmas cakes and Passover plava (a type of sponge cake sometimes made with matzo meal) are all identified primarily according to the celebration they are intended to accompany. The cutting of a wedding cake constitutes a social ceremony in some cultures. The Ancient Roman marriage ritual of *confarreatio* originated in the sharing of a cake.Particular types of cake may be associated with particular festivals, such as stollen or chocolate log (at Christmas), babka and simnel cake (at Easter), or mooncake. There has been a long tradition of decorating an iced cake at Christmas time; other cakes associated with Christmas include chocolate log and mince pies.

2.4 Shapes of Cake

Cakes are frequently described according to their physical form. Cakes may be small and intended for individual consumption. Larger cakes may be made with the intention of being sliced and served as part of a meal or social function. Common shapes include:

- Bundt cakes
- Cake balls

- Conical, such as the Kransekake
- Cupcakes and madeleines, which are both sized for a single person
- Layer cakes, frequently baked in a spring form pan and decorated
- Sheet cakes, simple, flat, rectangular cakes baked in sheet pans
- Swiss roll cakes

A finished cake is often enhanced by covering it with icing, or frosting, and toppings such as sprinkles, which are also known as "jimmies" in certain parts of the United States and "hundreds and thousands" in the United Kingdom. Frosting is usually made from powdered (icing) sugar, sometimes a fat of some sort, milk or cream, and often flavorings such as vanilla extract or cocoa powder. Some decorators use a rolled fondant icing. Commercial bakeries tend to use lard for the fat, and often whip the lard to introduce air bubbles. This makes the icing light and spreadable. Home bakers either use lard, butter, margarine or some combination thereof. Sprinkles are small firm pieces of sugar and oils that are colored with food coloring. In the late 20th century, new cake decorating products became available to the public. These include several specialized sprinkles and even methods to print pictures and transfer the image onto a cake.

Special tools are needed for more complex cake decorating, such as piping bags or syringes, and various piping tips. To use a piping bag or syringe, a piping tip is attached to the bag or syringe using a coupler. The bag or syringe is partially filled with icing which is sometimes colored. Using different piping tips and various techniques, a cake decorator can make many different designs. Basic decorating tips include open star, closed star, basketweave, round, drop flower, leaf, multi, petal, and specialty tips.

Royal icing, marzipan (or a less sweet version, known as almond paste), fondant icing (also known as sugarpaste) and buttercream are used as covering icings and to create decorations. Floral sugarcraft or wired sugar flowers are an important part of cake decoration. Cakes for special occasions, such as wedding cakes, are traditionally rich fruit cakes or occasionally Madeira cakes (also known as whisked or fatless sponge), that are covered with marzipan and either iced using royal icing or sugarpaste. They are finished with piped borders (made with royal icing) and adorned with a piped message, wired sugar flowers, hand-formed fondant flowers, marzipan fruit, piped flowers, or crystallized fruits or flowers such as grapes or violets Ayto, John (2002) and Casrella , Krystina (2010).

2.5 Present status of usage of artificial sweeteners

According to market analysts Mintel, a total of 3,920 products containing artificial sweeteners were launched in the US between 2000 and 2005. In 2004 alone, 1,649 artificially sweetened products were launched. According to market analysts Freedonia, the US artificial sweetener market is set to grow at around 8.3% per year to $189 million in 2008 (http:// encyclopedia. The free dictionary.com /Sugar + substitute # endnote_rf-1)

The Aspartame is currently the most popular sweetener in the US food industry, However, sucralose may soon replace it. According to Morgan Stanley, the price of sucralose will drop by 30% (http:// encyclopedia. The free dictionary.Com/ Sugar+ substitute# endnote_rf-2).

2.6 Sugar substitute

A sugar substitute, or artificial sweetener, is a food additive which attempts to duplicate the effect of sugar or corn syrup in taste, but usually with less food energy. Important classes of sugar substitutes are known as *high intensity sweeteners*. These

are compounds in which sweetness is many times that of sucrose; accordingly, much less sweetener is required and energy contribution often negligible. The sensation of sweetness caused by these compounds (the "sweetness profile") is sometimes notably different from sucrose, so they are used in complex mixtures that achieve the most natural sweet sensation Daniel et al (2000).

In the United States, five artificially derived sugar substitutes have been approved for use. They are saccharin, aspartame, sucralose, and neotame and acesulfame potassium. These compounds are all high intensity sweeteners. (http:// encyclopedia .the free dictionary. com / Sugar + substitute # endnote _ rf - 1, http:// encyclopedia. the free dictionary .com / Sugar+ substitute # endnote_rf-2).

The majority of sugar substitutes approved for food use are artificially synthesized compounds. However, some natural sugar substitutes (in addition to stevia) are known, including sorbitol and xylitol, which are found in berries, fruit, vegetables and mushrooms. (Although natural, they may be produced synthetically in bulk food production, to lower production costs.) Still other natural substitutes are known but are yet to gain official approval for food use.

Some non-sugar sweeteners are *polyols*, also known as "sugar alcohols." These are generally less sweet than sucrose, but have similar bulk properties and can be used in a wide range of food products. The list of Natural and artificial sugar substitute is as under:

Natural sugar substitutes:

S. No.	Name	Nature and class
1.	Brazzein	Protein, 800× sweetness of sucrose (by weight), Exxx
2.	Curculin	Protein, 550× sweetness (by weight), Exxx
3.	Erythritol	0.7×sweetness (by weight), 14× sweetness of sucrose (by food energy), 0.05× energy density of sucrose
4.	Fructose	1.7× sweetness (by weight and food energy), 1.0× energy density of sucrose
5.	Glycyrrhizin	50× sweetness (by weight)
6.	Glycerol	0.6× sweetness (by weight), 0.55× sweetness (by food energy), 1.075× energy density, E422
7.	Hydrogenated starch hydrolysates	0.4×–0.9× sweetness (by weight), 0.5×–1.2× sweetness (by food energy), 0.75× energy density
8.	Lactitol	0.4× sweetness (by weight), 0.8× sweetness (by food energy), 0.5× energy density, E966
9.	Mabinlin	Protein, 100× sweetness (by weight), Exxx
10.	Maltitol	0.9× sweetness (by weight), 1.7× sweetness (by food energy), 0.525× energy density, E965
11.	Maltooligosaccharide	
12.	Mannitol	0.5× sweetness (by weight), 1.2× sweetness (by food energy), 0.4× energy density, E421
13.	Miraculin	Protein, *n*× sweetness (by weight), Exxx
14.	Monellin	Protein, 3,000× sweetness (by weight), Exxx
15.	Pentadin	Protein, 500× sweetness (by weight), Exxx
16.	Sorbitol	0.6× sweetness (by weight), 0.9× sweetness (by food energy), 0.65× energy density, E420
17.	Stevia	250× sweetness (by weight)
18.	Tagatose	0.92× sweetness (by weight), 2.4× sweetness (by food energy), 0.38× energy density
19.	Thaumatin	Protein, 2,000× sweetness (by weight), E957
20.	Xylitol	1.0× sweetness (by weight), 1.7× sweetness (by food energy), 0.6× energy density, E967

Artificial sugar substitutes

Note that because many of these have little or no food energy, comparison of sweetness based on energy content is not meaningful.

S. No.	Name	Nature and class
1.	Acesulfame potassium	200× sweetness (by weight), Nutrinova, E950, FDA Approved 1988
2.	Alitame	2,000× sweetness (by weight), Pfizer, Pending FDA Approval
3.	Aspartame	160–200× sweetness (by weight), NutraSweet, E951, FDA Approved 1981
4.	Aspartame-Acesulfame-Salt	350× sweetness (by weight), Twinsweet, E962
5.	Cyclamate	30× sweetness (by weight), Abbott, E952, FDA Banned 1969, pending re-approval
6.	Dulcin	250× sweetness (by weight), FDA Banned 1950
7.	Neohesperidin dihydrochalcone	1,500× sweetness (by weight), E959
8.	Neotame	8,000× sweetness (by weight), NutraSweet, FDA Approved 2002
9.	P-4000	4,000× sweetness (by weight), FDA Banned 1950
10.	Saccharin	300× sweetness (by weight), E954, FDA Approved 1958
11.	Sucralose	600× sweetness (by weight), Tate & Lyle, E955, FDA Approved 1998
12.	Isomalt	0.45×–0.65× sweetness (by weight), 0.9×–1.3× sweetness (by food energy), 0.5× energy density, E953

2.7 Sucralose

Sucralose was discovered in 1976 by scientists from Tate & Lyle. Sucralose is an artificial sweetener that has the generic name Altern. In the European Union, it is also known under the E

number (additive code) E955. Sucralose is sold under the trade name Splenda. Sucralose is approximately 600 times sweeter than

Sucrose(tablesugar),http://encyclopedia.thefreedictisonary.com/Sugar+substitute#endnote_rf-2 twice as sweet as saccharin, and four times as sweet as aspartame. Unlike aspartame, it is stable under heat and over a broad range of pH conditions and can be used in baking or in products that require a longer shelf life. Since its introduction in 1999 sucralose has overtaken Equal in the $1.5 billion artificial sweetener market, holding a 62% marketshare. http://encyclopedia. thefreedictionary.com / Sucralose#endnote_rf-3. According to market research firm IRI, as reported in the Wall Street Journal, Splenda sold $212 million in 2006 in the US while Equal sold $48.7 million.

It was first approved for use in Canada (marketed as Splenda) in 1991. Subsequent approvals came in Australia in 1993, in New Zealand in 1996, in the United States in 1998, and in the European Union in 2004. As of 2006, it had been approved in over 60 countries, including Brazil, China, India, United States, and Japan.

It is manufactured by the selective chlorination of sucrose, in which three of the hydroxyl groups are replaced with chlorine atoms to produce 1,6-dichloro-1,6-dideoxy-β-D-fructo-furanosyl 4-chloro-4-deoxy-α-D-galactopyranoside or $C_{12}H_{19}Cl_3O_8$.

It is used in products such as candy, breakfast bars and soft drinks. Sucralose can be found in more than 4,500 food and beverage products. Sucralose is a highly heat-stable artificial sweetener, allowing it to be used in many recipes without any use of sugar. Sucralose is available in a granulated form that allows for cup-for-cup substitution with sugar.

Sucralose mixed with maltodextrin and dextrose (both made from corn) as a filler is sold internationally by McNeil Nutritionals under the Splenda brand name. In the United States and Canada, this blend is increasingly found in restaurants, including McDonalds and Starbucks, in yellow packets, in contrast to the pink packets commonly used by saccharin sweeteners and the blue packets used by those containing aspartame; though in Canada yellow packets are also associated with the Sugar Twin brand of cyclamate sweetener.

In the U.S. market sold as a “No calorie sweetener,” Splenda actually contains slightly more calories than the same mass of sugar (391 kcal per 100 g vs. 390 kcal per 100 g for whitegranulatedsugar).http://encyclopedia.thefreedictionary.com/Sucralose#endnote_rf-5 when sucralose is added directly to commercial products, the filler is omitted and no calories are added. Labeling is appropriate in the U.S. because the FDA’s regulations permit a product to be labeled as “zero calories” Sucralose is used as a replacement for, or in combination with, other artificial or natural sweeteners such as aspartame, acesulfame potassium or high-fructose corn syrup.

Sucralose has been accepted by several national and international food safety regulatory bodies, including the U.S. Food and Drug Administration (FDA), Joint Food and Agriculture Organization/World Health Organization Expert Committee on Food Additives, The European Union’s Scientific Committee on Food, Health Protection Branch of Health and Welfare Canada and Food Standards Australia-New Zealand (FSANZ). According to the Canadian Diabetes Association, one can consume 15 mg/kg/day of Sucralose "on a daily basis over a lifetime without any adverse effects

"http://encyclopedia.thefreedictionary.com/Sucralose#endnote_rf-8. For a 150-lb person, 15 mg/kg is about 1000 mg, equivalent

to about 75 packets of Splenda or the sweetness of 612 gm or 2500 kcal of sugar.

The bulk of sucralose ingested does not leave the gastrointestinal tract and is directly excreted in the feces while 11-27%o fit is absorbed.

http://encyclopedia.thefreedictisonary.com/Sugar+substitute#endnote_rf-2.The amount that is absorbed from the GI tract is largely removed from the blood stream by the kidneys and excreted in the urine with 20-30% of the absorbed sucralose beingmetabolized.http://encyclopedia.thefreedictisonary.com/Sugar+substitute # endnote_rf-2. Sucralose is digestible by a number of microorganisms and is broken down once released into the environment.

Splenda usually contains 95% dextrose (the "right-handed" isomer of glucose - see dextrorotation and chirality), which the body readily metabolizes. The safety information that many specialists and the media give to consumers is that Splenda is safe to ingest as a diabetic sugar substitute "free of problems".

2.8 Natural alternative of sugars

Critics of sucralose often favor natural alternatives, including xylitol, maltitol, thaumatin, isomalt, and Stevia. However, those substances raise other health concerns, and natural products generally do not undergo controlled trials before being allowed in food.

Whole Foods Market, a U.S. based retailer of natural and organic foods, has a policy of not carrying products containing sucralose. The retailer’s statement regarding this decision made allegations revolving around five essential points:

1. Sucralose is an artificial substance, some of which is absorbed by the body
2. Pre-approval tests indicated a potential for toxicity

3. Sucralose is a chlorinated compound (a chlorocarbon)
4. Independent, controlled human studies had not been performed
5. Long-term human studies with sucralose had not been performed(http://encyclopedia.thefreedictionary.com/sucralose#endnote_rf-15) .

2.9 Utilization of Sugar Substitute in bakery products and their effect on quality:

Kulp, Lorenz, and Stone, 1991; Ngo and Taranto, 1986; Shukla, 1995; Spies and Hoseney, 1982 reported that Sucrose is a principal ingredient in sponge cakes, and its role extends beyond providing energy and sweetness. In consequence, it cannot be substituted only by intense sweeteners. It acts as a tenderiser by retarding and restricting gluten formation, increasing the temperatures of egg protein denaturation and starch gelatinization, and contributing to bulk and volume Therefore, the reduction of sucrose levels in a cake system affects structural and sensory properties (Frye & Setser, 1991, Altschul, 1993).

Wallis, (1993) reported that Sucrolase is a non sugar sweetener provides about 600 times of sucrose sweetness with no unpleasant residual flavour, non- caloric, non- cariogenic and proven as safe for human consumption).

Hess and Setser, (1983) and Attia *et al*. (1993) reported that replacement of sucrose by using sugar substitutes alone (xylitol, sorbitol, acesulfame- k, aspartame saccharin) or their combinations at levels of above 25 % resulted in a decrease in the quality and acceptability of cakes consequently, it is important to find an alternative sugar substitute to traditional sugars in order to improve the quality of cake.

Greig *et al.* (1985) and Fellows *et al.* (1991) reported the use of aspartem in dairy products. The studied showed that

artificially sweetened yoghurt with aspartame was found to have excellent viscosity, a sharp nutty flavor and a significantly reduced energy value.

Beereboom, 1979; Deis, 1993 and Giese, 1993 reported that Bulking agents, which replace the nonsweet functional characteristics of sucrose, can be used as alternatives to sucrose in bakery products, but none of them possess all properties of sucrose's.

Hess and Setser (1983) tested layer cakes sweetened with aspartame, and found that its combination with low levels of fructose led to cakes more tender, more uniform and with higher overall eating quality than the non-bulking aspartame layer cakes.

Keller *et al.* (1991) also reported that lactose treated aspartame sweetened frozen desert also had greater acceptability as compared to standard formulation containing aspartame along with bulking agents.

Frye and Setser (1991) reported a successful textural optimization of sponge cakes, replacing sucrose by bulking agents, but found that polydextrose – included in the optimized formula – had some bitter or astringent aftertaste and mouth-drying effect.

Attia, Shehata, and Askar (1993) proposed a formula involving fructose, polydextrose, and non-nutritive sweeteners, which led to sponge cakes with similar acceptability to that of sugar cake with a 40% reduction in calories.

Knecht, (1990) and Newsome, (1993) reported that high sugar and fat content of cake increases the total calorie of product, over consumption may contribute to high risk of health problems such as coronary diseases, high blood pressure and cholesterol diabetes, obesity and some cancers.

Pateras, Howells, and Rosenthal (1994) reported the effect of sucrose replacement by polydextrose on foam characteristics of cake batters. Polydextrose caused an increase in the mean size of air bubbles, and introduced a larger variation in bubble size distribution in the cake batter.

Goossens and Roper, (1994), and Munro *et al*. (1998) reported Erythritol, a 4- carbon sugar alcohol with about 60-80% of the sucrose sweetness, can be used in low- calorie foods because it provides less than 0.5 Kcal/g with no increase in blood glucose and insulin, non- cariogenic and non- toxic substance

Baeva, Panchev, and Terzieva (2000) studied the effect of total replacement of sucrose by microencapsulated aspartame and bulking agents, such as sorbitol, wheat starch, and wheat germ, on physical and textural sensory characteristics of sponge cakes. They reported the substantial differences among sugar-free cakes and the control one.

Hicsasmaz, Yazgan, Bozoglu, and Katnas (2003) reported the above same increase in the mean bubble size and showed that polydextrose was capable of imitating the sucrose cake batter in terms of bubble size distribution. Also, they found that increase in polydextrose resulted in a significant decrease in cake height and a sensible change in the lightness and in the crumb colour hue.

Jayaprakash (2003) reported the use of 41.77% sorbitol and 0.08% aspartame in rasogolla. The product had desirable shape, softness and porosity and aspartame did not affect the sensory quality of the product except its sweetness.

Ramakrishna *et al.* (2005) studied moisture sorption characteristics of milk burfi, using sugar substitute and found the product prepared using replacing sugar with sorbitol,

maltodextrin and polydextrose, and PD alone, along with aspartame to give an equi-sweetness level compared to sugar.

Felicidad Ronda, Manuel Gómez, Carlos A. Blanco, Pedro A. Caballero ( ) reported the, interest in nutrition driving consumer demands for less fat, sugar, and calories. In most foods, the removal or reduction of ingredients causes readily detectable losses in appearance, texture and mouthfeel. He reported used of maltitol, mannitol, xylitol, sorbitol, isomaltose, oligofructose and polydextrose as bulking agents totally replace of sucrose in sponge cakes. The effect of this substitution on cake quality was determined by measuring texture, colour and volume after baking under controlled conditions. These parameters were established instrumentally and by sensory evaluation. The results shows that xylitol and maltitol, leading to sponge cakes more similar to the control one – manufactured with sucrose – and with the highest acceptance level in sensory evaluations. Lower quality sponge cakes were those elaborated with mannitol.

Arora *et al.* (2007) the result of the sensory evaluation had showed the successful use of low calorie sweeteners in the preparation of burfi with a slight difference in its overall acceptability compared to the conventional burfi.

Shradha and Geetanjali, (2008) observed that Calorie free digestive biscuit could be stored at room temperature for 30 – 45 days with minimum deterioration in quality followed by cold storage if needed.

Sharma *et al.* (2008) developed a low calorie RTS by varying levels of aonla (Var. Krishna) and lime juices and found that 50% of sugar can be replaced by stevia in the preparation of low calorie RTS which shall be beneficial for obese and diabetic consumer.

Murlidhara and Balasubramanyam (2008) studied the effect of partial replacement of sugar with different artificial sweeteners on sensory quality of shrikhand and reported that none of the artificial sweeteners tried could impart desired sweetness in shrikhand, even at the maximum levels permitted by PFA. Also there was no significant difference in sensory scores between the samples made by using artificial sweeteners in combination with selected levels of sugar and control sample.

Arora *et al.* (2009) repotted that sucralose sweetened burfi posses the same desirable sweetness, colour and texture even after seven days after storage at 6-8^0 C The titrable acidity was higher than in controlled sample. Total plate count increased linearly for both sucralose sweetened burfi and control during storage.

Marshall *et al.* (2009) reported enhancement in the sensory quality and settling of curd in low calorie lassi using maltodextrin and sucralose

Berglund and Hertsgaard (1986) used vegetable oils at reduced levels in cake, pie crust, cookies and muffins and concluded that drop sugar cookies made from oils were similar in flavour to those made with shortening but were less liked for appearance, crispness and overall preference.

Prasad (1988) prepared a coperecipitate from skim milk and used at 10 per cent in cake and biscuits mixes. Products were evaluated for nutritional quality, organoleptic acceptability and storage life. The products were acceptable, had about 5 per cent more protein, were equally shelf stable and were cheaper to produce than controls (made with conventional skim milk).

Lakshminarayan, Rathinam, and KrishnaRau, (2006), reported the effect of fat replacement by maltodextrin on cake batter viscosity and the quality of the resultant cakes. The viscosity of batter was reduced significantly when fat was

replaced with equal quantities of maltodextrin. Cakes prepared from this batter had low volume and firmer texture. Relatively better cakes were obtained when lower quantities of maltodextrin were used in the formulation. Viscosity of the above cake batter was relatively higher. A relationship between batter viscosity and cake volume was observed. Further improvement in cake volume could be achieved using emulsifiers. In the presence of glycerol monostearate little improvement in cake batter was observed, but the resultant cake volume was improved. However, sodium steroyl lactylate, which improved the batter viscosity, did not improve the cake volume or texture.

After doing the critical appraisal towards literature, it reveals that the information is still quite meager on optimization of levels of sucrolase and baking ingredients in cake preparation. With the changing demand towards the nutritional consciousness new baking ingredients are required to be evaluated for Cake preparation. Therefore, the present investigation has been undertaken and the findings are given in next chapters.

MATERIALS AND METHODS

This chapter deals with the various experimental technique materials and methodologies used for preparation of sugar free cake using sucralose and other baking ingredients. The present investigation was carried out in the Department of Food Science and Technology, College of Agriculture, JNKVV, Jabalpur (M.P.) during the year 2011-12

3.1 Materials

The refined wheat flour (maida) and various ingredients such as Sugar, Sugar free substance (Sucralase), shortening (fat), Milk Powder, Baking powder and sodium bi carbonate were purchased from the Priya Darshani Cooperative Store Adhartal Jabalpur. All the chemicals used in present investigation were of standard analytical grades from BDH (India), E-Merck Sarabhai, M. (Guaranteed) and glasswares used in the present investigation were of Qualigens, Bombay and Borosil, respectively.

3.2 Preparation of Cake

The cake was prepared by following the standard procedure as describe by, the following formulation of baking ingredients were selected for preparation of sugar free cake

The sugar free cake from wheat flour (control) and Blends (composite of, Sugar free(Sucralose) Fat, Milk powder ,Baking Powder and Sodium bi carbonate) were prepared using the method as described by AACC (1969) Following general formula has been used for product preparation.

Formula

Ingredients	Quantity
Wheat flour	80 gm
Sugar	80 gm
Shortening (fat)	35 gm
Milk powder	50 gm
Baking powder	02 gm
Sodium bicarbonate	1.13gm
Water	80ml

Sugar free (sucralose) has been used in place of sugar.

Ingredients specifications:

1. Sugar, Baker's Special or equiv. in fine- granulated sucrose.
2. Shortening. Baker's hydrogenated emulsifier- type shortening. It should be plastic and workable at room temperature and be free of any undesirable color, odor, or flavor.
3. Milk, use dried milk conforming to specifications for extra grade nonfat dry milk as established by American Dairy Milk Institute. Max. analytical tolerances are: butterfat, 1.25%; moisture, 4.0%; titratable acidity, 0.15%; solubility index, 1.25 ml.; bacterial estimate, 50,000/g.; and scorched particles, Disc B (15.0 mg.). It must be entirely free of lumps except those that break up under slight pressure. Product when reliquaries must have sweet and desirable flavor.
4. Baking powder. Baker's double-action, especially formulated for high-ratio cakes (MCP and SAPP recommended). Do not use if more than 6 months' time has elapsed since purchase. Weigh out required quantity on day of bake. Follow schedule below to det. quantity to use.
5. Water. Use distilled water only.

Method:

1. Bring oven to baking temp., and condition it by baking cake using scrap batter and above formula.
2. Combine all dry ingredients except shortening, and sift well. Transfer to mixing bowl, add shortening and 60% of water. Mix at low speed for 0.5 min., scrape down, and mix at medium speed for 4 min. Add

one-half of remaining water, mix at low speed for 0.5 min., scrape down, and mix at medium speed for 2 min. Add remaining water, mix at low speed for 0.5 min., scrape down, and mix at medium speed for 2 min.

3. Grease pans lightly with commercial pan grease (1st choice) or nonemulsified shortening (2nd choice). Line bottom with parchment paper. Scale 425 g. batter into each of two pans and bake at 375°F. (1st choice) or 350°F. (2nd choice) until done.
4. Cool cakes in pans for about 30 min., remove from pans, and continue cooling. Dust lightly with flour before measuring. **If** vol. detn. and texture scoring are to be delayed for more than 4 hr., dust cake lightly with flour and wrap with polyvinyl chloride film or equiv. material at time of depanning. Remove wrapping and redust for vol. detn. and scoring. Cakes should be graded for vol. and texture on same day as bake.

3.3 Experimental plan and design

To replace table sugar sucrose with sugar free substance sucralose, there was also need of varying the proportion of other ingredients included in the formulation for getting optimum quality of product. Hence four variables viz sugar free (Sucrolase), Fat, Milk Powder, Baking powder and Sodium bicarbonate were selected for optimization of formulation. The ranges of variables were selected taking into consideration the maximum and minimum values used for Cake preparation. Responses surface methodology (Mayer's, 1976) was used to reduce the number of experiments, without affecting the accuracy of result. The experimental plan was consisted of 50 experiments. First 32 experiments in first order part, 10 experiments in second order part and next 8 experiments were at central point or replication.

Table 3.1 Experimental variables their coded and decoded (actual) values for production of sugar free cake

S.No.	Variable	Code	Coded level				
			-2.3784[a]	-1	0[b]	+1	2.3784[a]
1	Sucrolase* (g)	X_1	1.04	1.6	2	2.4	2.95
2	Fat (g)	X_2	23.11	30	35	40	46.89
3	Milk power (g)	X_3	23.22	40	50	60	73.78
4	Baking powder (g)	X_4	0.81	1.50	2	2.50	3.19
5	Sodium bicarbonate(g)	X_5	0.23	0.75	1.13	1.50	2.02

a: $\pm\propto$ values

b: center point

Abbreviations:

S = Sucralose

F = Fat

MP = Milk powder

BP = Baking powder

SB = Sodiumbicarbonate

* The level of sucralose and Sugar were selected @25:75 percent respectively in view of preliminary experimental trials (fig). The 8 g of sucrolase is equivalent to 80 g of sugar.

Table 3.2 Experimental design matrix for production of Sugar free cake

Expt.No.	Coded form					Decoded form				
	X_1	X_2	X_3	X_4	X_5	Sucrolase (%) X_1	Fat (g) X_2	Milk Powder (g) X_3	Baking Powder (g) X_4	Sodium bicarbonate (g) X_5
First order interaction										
1	-1.00	-1.00	-1.00	-1.00	-1.00	20.00	30.00	40.00	1.50	0.75
2	1.00	-1.00	-1.00	-1.00	-1.00	30.00	30.00	40.00	1.50	0.75
3	-1.00	1.00	-1.00	-1.00	-1.00	20.00	40.00	40.00	1.50	0.75
4	1.00	1.00	-1.00	-1.00	-1.00	30.00	40.00	40.00	1.50	0.75
5	-1.00	-1.00	1.00	-1.00	-1.00	20.00	30.00	60.00	1.50	0.75
6	1.00	-1.00	1.00	-1.00	-1.00	30.00	30.00	60.00	1.50	0.75
7	-1.00	1.00	1.00	-1.00	-1.00	20.00	40.00	60.00	1.50	0.75
8	1.00	1.00	1.00	-1.00	-1.00	30.00	40.00	60.00	1.50	0.75
9	-1.00	-1.00	-1.00	-1.00	-1.00	20.00	30.00	40.00	2.50	0.75
10	1.00	-1.00	-1.00	1.00	-1.00	30.00	30.00	40.00	2.50	0.75
11	-1.00	1.00	-1.00	1.00	-1.00	20.00	40.00	40.00	2.50	0.75
12	1.00	1.00	-1.00	1.00	-1.00	30.00	40.00	40.00	2.50	0.75
13	-1.00	-1.00	1.00	1.00	-1.00	20.00	30.00	60.00	2.50	0.75
14	1.00	-1.00	1.00	1.00	-1.00	30.00	30.00	60.00	2.50	0.75
15	-1.00	1.00	1.00	1.00	-1.00	20.00	40.00	60.00	2.50	0.75
16	1.00	1.00	1.00	1.00	-1.00	30.00	40.00	60.00	2.50	0.75
17	-1.00	-1.00	-1.00	-1.00	1.00	20.00	30.00	40.00	1.50	1.50
18	1.00	-1.00	-1.00	-1.00	1.00	30.00	30.00	40.00	1.50	1.50
19	-1.00	1.00	-1.00	-1.00	1.00	20.00	40.00	40.00	1.50	1.50
20	1.00	1.00	-1.00	-1.00	1.00	30.00	40.00	40.00	1.50	1.50
21	-1.00	-1.00	1.00	-1.00	1.00	20.00	30.00	60.00	1.50	1.50
22	1.00	-1.00	1.00	-1.00	1.00	30.00	30.00	60.00	1.50	1.50
23	-1.00	1.00	1.00	-1.00	1.00	20.00	40.00	60.00	1.50	1.50
24	1.00	1.00	1.00	-1.00	1.00	30.00	40.00	60.00	1.50	1.50
25	-1.00	-1.00	-1.00	1.00	1.00	20.00	30.00	40.00	2.50	1.50
26	1.00	-1.00	-1.00	1.00	1.00	30.00	30.00	40.00	2.50	1.50
27	-1.00	1.00	-1.00	1.00	1.00	20.00	40.00	40.00	2.50	1.50
28	1.00	1.00	-1.00	1.00	1.00	30.00	40.00	40.00	2.50	1.50
29	-1.00	-1.00	1.00	1.00	1.00	20.00	30.00	60.00	2.50	1.50
30	1.00	-1.00	1.00	1.00	1.00	30.00	30.00	60.00	2.50	1.50
31	-1.00	1.00	1.00	1.00	1.00	20.00	40.00	60.00	2.50	1.50
32	1.00	1.00	1.00	1.00	1.00	30.00	40.00	60.00	2.50	1.50
Secondary order interaction										
33	-2.38	0.00	0.00	0.00	0.00	13.11	35.00	50.00	2.00	1.13
34	2.38	0.00	0.00	0.00	0.00	36.89	35.00	50.00	2.00	1.13
35	0.00	-2.38	0.00	0.00	0.00	25.00	23.11	50.00	2.00	1.13
36	0.00	2.38	0.00	0.00	0.00	25.00	46.89	50.00	2.00	1.13
37	0.00	0.00	-2.38	0.00	0.00	25.00	35.00	26.22	2.00	1.13
38	0.00	0.00	2.38	0.00	0.00	25.00	35.00	73.78	2.00	1.13
39	0.00	0.00	0.00	-2.38	0.00	25.00	35.00	50.00	0.81	1.13
40	0.00	0.00	0.00	2.38	0.00	25.00	35.00	50.00	3.19	1.13
41	0.00	0.00	0.00	0.00	-2.38	25.00	35.00	50.00	2.00	0.23
42	0.00	0.00	0.00	0.00	2.38	25.00	35.00	50.00	2.00	2.02
Centre point										
43	0.00	0.00	0.00	0.00	0.00	25.00	35.00	50.00	2.00	1.13
44	0.00	0.00	0.00	0.00	0.00	25.00	35.00	50.00	2.00	1.13
45	0.00	0.00	0.00	0.00	0.00	25.00	35.00	50.00	2.00	1.13
46	0.00	0.00	0.00	0.00	0.00	25.00	35.00	50.00	2.00	1.13
47	0.00	0.00	0.00	0.00	0.00	25.00	35.00	50.00	2.00	1.13
48	0.00	0.00	0.00	0.00	0.00	25.00	35.00	50.00	2.00	1.13
49	0.00	0.00	0.00	0.00	0.00	25.00	35.00	50.00	2.00	1.13
50	0.00	0.00	0.00	0.00	.00	25.00	35.00	50.00	2.00	1.13

3.4 Analytical methods

The following methods were used for various determinations.

3.4.1 Physical properties of sugar free cake

3.4.1.1 Diameter

The Diameter of cake was measured by laying cake measuring to the nearest mm (A.A.C.C. 1967).The cake was rotated at 90^0 and their diameter was remeasured as a check determination the average diameter of cake was reported in centimeter.

3.4.1.2 Thickness

Thickness of cake was measured by vernire calipers. The average value of six determinations were taken and reported in centimeter (A.A.C.C. 1967).

3.4.1.3 Volume of Cake

The volume of sugar free cake was determined by rapeseed displacement or equivalent method. The results were expressed as grams of rapeseed displaced.

3.4.1.4 Density of Cake

This was calculated by dividing average weight of cake by average volume of cake. The results were expressed as ml/g.

3.4.1.4 Weight

The weight of sugar free cake was determined using electronic scale. The average of three determinations is reported in gram (g).

3.4.2 Chemical properties of sugar free biscuits

3.4.2.1 Moisture

The moisture content in the sample was estimated according to the method of AOAC (1984). 5 gm of sample was

taken in pre-weighed moisture box, dried at 105ºc for 24 hrs in hot air oven, cooled in desiccators again weighed. The difference in weight of moisture box represents the moisture content of the sample.

$$\text{Moisture (\%)} = \frac{\text{Difference in the weight}}{\text{Weight of the sample}} \text{ X } 100$$

3.4.2.2 Protein

The protein content in sample was determined by using conventional Micro-Kjeldhal digestion and distillation procedure as given in AOAC (1984).

Reagents

(a) Catalyst mixture- A mixture of 100 gm K_2SO_4, 20gm of $CuSO_4$ and 2.5 gm of Sio2.

(b) Sodium hydroxide 40%(w/v)

(c) Boric acid 2 %(w/v).

(d) Concentrated sulphuric acid AR (spgr 1.81)

(e) Mixed indicator 2 parts 0.2 %(w/v) Methyl red and 1 parts 0.2% (w/v) methyl blue in absolute alcohol.

(f) Standard sulphuric acid (0.1N)

Procedure

0.5 gm of sample was weighed accurately and transferred to a Kjeldhal flask taking care to see that the material did not stick to the neck of the flask. The catalyst mixture of about 1g and concentrated sulphuric acid (5ml) were added. Then the flask in an inclined position in digestion chamber was heated for about 4-6 hours till the liquid became clear (green blue colour).

Distillation

The content in the flask were allowed to cool and the digestion material was transferred quantitatively to a vacuum

jacketed flask of micro Kjeldhal distillation apparatus and the ammonia liberated by the addition of 10 ml of 40% Noah on heating was absorbed in 20 ml boric acid containing 2-3 drops of mixed indicator in 100ml conical flask. The distilled off ammonia was titrated against 0.1N sulphuric acid. The blank was also run in a similar way.

$$N\ (\%) = \frac{\text{Normality of } H_2SO_4 \text{ X Volume of 0.1N } H_2SO_4 \text{ X 14}}{\text{Weight of sample X 1000}} \text{ x 100}$$

Crude protein (%) = N X 6.25

3.4.2.3 Fat

The fat content of the sample was determined by the procedure as described in AOAC (1984). 5 gm of sample was weighed accurately, placed in thimble and plugged with cotton. The extractor-containing thimble was placed over a pre weighed extraction flask (A). Fat content was determined by extracting the sample with solvent petroleum ether (AR grade 60-80°c) for 8 hr using soxhlets extraction procedure. After extraction the excess of solvent was distilled off and the residual solvent was removed by heating at 80°c in oven for 4-6 hours. The fat content was determined as below:

$$\text{Crude fat (\%)} = \frac{\text{Weight of flask (b)-weight of flask (A)}}{\text{Weight of sample}} \text{ X 100}$$

3.4.2.4 Carbohydrate

Total carbohydrate in the samples was estimated by hydrolysis method as described in AOAC (1984).

Reagents:

1. Conc. HCl (AR sp gr 1.25)
2. Fehling's solution

- Fehling's solution A: 34.64 gm of $CuSO_4.5H_2O$ was dissolved in 500ml of distilled water.

- Fehling's solution B: 173 gm of sodium potassium tartarate and 50 g of sodium hydroxide were dissolved in 500 ml of distilled water. The Fehling's solution was prepared by mixing the equal volume of solution A and solution B. It was prepared fresh daily.

3. Sodium Hydroxide 40 %(w/v).
4. Methyl blue indicator 0.1 % (w/v) in 95% alcohol.
5. 3N HCl – 68.18 ml concentrated HCl was made up to 250 ml with distilled water.
6. Dextrose 1%- 1 gm of dextrose was dissolved in 100 ml distilled water.

Procedure:

2.5gm sample was taken in the flask and suspended in 200 ml of distilled water. 20ml of 3N HCl was added refluxed in an air condenser for 3 hrs. On cooling, it was neutralized with alkali to pH 7.0, filtered and volume was made to 250 ml with distilled water.

The total carbohydrate in the filtrate was determined by titrating it with Fehling's solution (A & B, %ml each) using 1 ml of methyl blue indicator. Factor was worked out by titrating 1% dextrose with Fehling's solution. In each titration Fehling's solution in the conical flask was heated with a constant flame and titration was done with filtrate in the burette until the end point (Brick- Red colour) was obtained. The total carbohydrate content was calculated as under.

$$\text{Dextrose \%} = \frac{\text{Factor x 250}}{\text{Titrated value X weight of sample}} \text{X 100}$$

Total carbohydrate (%) = Dextrose % X 0.9

3.4.2.5 Total Sugar, Reducing and Non Reducing sugar

The total Sugar, reducing and non reducing sugar content in the sugar free cake was estimated by following the standard procedure as described by Ranganna (1991).

3.5 Sensory evaluation of sugar free Cake

A semi trained panel of 10 members was given samples of Cake to evaluate the following sensory quality attributes viz., Cell, Grain, Texture, Crumb Colour, Flavour, and total Score. A 100 point Score card (Appendix-I) has been used as describe in AACC (1967). The data were statistically analyzed by standard procedure as described by Mayeras (1976).

3.6 Statistical analysis

The data obtained from each experiment were processed on a Pentium IV computer using Design Expert 8.1 software. Response surface graph of selected response were developed to study the effect of independent variables and optimize the level of ingredients. The review of literature related to present investigation and findings of experiments are presented in subsequent chapter.

RESULTS

The present investigation deals with the optimization of levels of sugar substitute i.e. sucralose and other baking ingredients for productions of sugar free cake. The findings of the various experiments are presented in this chapter.

A RSM (Myers 1976) was selected as the approach to determine levels of sucralose (X_1), fat (X_2), milk powder (X_3), baking powder (x_4), sodium bicarbonate (x_5). Five levels of each independent variable were chosen (Tables 3.1, 3.2). The central composite rotatable design with half replicate was used to determine the combination of variable levels in each experiment. Experimental plan was consisted of 50 experiments, out of them 32, 10 and 8 experiments were in first order, second order interactions and center point, respectively. To determine the effect of independent variable on some predominant responses viz. physical properties, sensory quality attribute and chemical composition of product response surface methodology was used. A full second order equation of following form was fitted in each response to describe it mathematically and to study the effect of variables.

$$Y = \beta 0 + \sum_{i=1}^{4} \beta i\, Xi + \sum_{i=1}^{3} \sum_{j=i+1}^{4} \beta ij\, Xi\, Xj + \sum_{i=1}^{4} \beta i\, Xi^2$$

The adequacy of models was tested using F ratio and coefficient of determination (R^2). The model is generally considered adequate when (I) the calculated F ratio was more than that of table value and (II) the R^2 value is more than 70% (Frazier et al, 1983, Henika, 1982). The effect of variables at liner, quadratic and interactive levels on the response was described using significance at 1 and 5 % level of confidence. In order to predict the responses simple models are required. Hence, all non-significant terms of full second order polynomial

model for each response of sugar free cake were removed and stepwise regression analysis was done. The best-fit empirical equations thus developed did not sacrifice the accuracy of results.

The result of the data obtained from various experiments for physical properties, chemical composition and sensory quality attributes are given in Section 4.1, 4.2, 4.3 through Table 4.1 to 4.15. The effect of variables on predominant response is presented in Fig. 1 to Fig.30.

4.1 Physical properties of Sugar free cake

4.1.1 Thickness

The Table 4.1 comprises the results of effect of ingredients level on thickness of sugar free cake. Thickness was highest at Expt. 29 (7.5cm) and lowest at Expt. 37 (4.7cm). These experiments represented the combination of the ingredients as 20%, 30g, 60g, 2.5g 1.5g, and 25%, 35g, 26.22, 2g and1.13 g of sucralose, fat, milk powder, baking powder and sodium bicarbonate, respectively. The analysis of variance table for full second order regression model (Table 4.3) indicates that the F-ratio of the model (14.93) was higher as compared with the table value of 1.94 at 5 per cent level of significance. R^2 value of model was 91 per cent. The model was found adequate for further analysis.

Table 4.2 indicates that thickness of cake was significantly affected by addition of baking ingredients. The linear effect sucralase, Milk powder, Baking powder and Sodium bicarbonate were highly significant at 1% level of confidence. The interactions of sucrolose- fat, sucrolose – baking powder, milk powder–sodium bi carbonate and baking powder-sodium bi carbonated were significant.

The quadratic effect of sucrolose, fat and sodium bi carbonate shows positive significant effect on thickness of cake.

The rest of the interactions and quadratic term of model were non-significant even at 10% level of significance.

4.1.2 Volume

The effect of different ingredient and their combination on volume of cake is given in Table 4.1 The maximum and minimum volume 840 cc/g and 643 cc/g was recorded in Expt. 3 and 21 respectively, which represented the combination of ingredients to be 20%, 40g, 40g, 1.5 g, 0.75g, and 20%, 30g, 60g, 1.5g, 1.5 of Sucralose, Fat, Milk Powder and Sodium Bi carbonate and baking powder respectively. The F-ratio and its table value are given in Table 4.3. The table indicates that F-ratio 9.67 was higher as compared to table value of 1.94. The R^2 value of perdition model was 86%. The findings indicate that model was significant and could explain more then 86% variability in the experiments.

Table 4.2 indicates that the linear effect of Milk powder, and Sodium bicarbonate were highly significant at 1% level of confidence. The interactions and quadratic of various ingredients were non-significant even at 10% level of significance.

4.1.3 Density

The density sugar free cake was highest at Expt.31 and lowest at Expt.2. It ranges from 0.31-0.43 g/cc. The highest and lowest was observed in the product made from combination of ingredients viz. 20%, 40g ,60g, 2.5g, 1.5g, and 30%, 30g, 40g, 1.5g, 075g. Sucralose, Fat, Milk powder Baking powder, and Sodium bi carbonate, respectively. The F-ratio and its table value are given in table 4.3. The table indicates that F-ratio (7.74) was higher as compare to table value of 1.94. The R square value of perdition model was 84%

Table 4.2 shows that density of cake was significantly affected by addition of baking ingredients. The simple effect of levels of sucralase, Milk powder and Sodium bicarbonate were highly significant at 1% level of confidence. The interaction of

baking powder–sodium bi carbonate was also significant at 1% level of significance. The rest of the interactions and quadratic term of model were non-significant even at 10% level of significance.

4.1.4 Weight

The weight of sugar free cake varied from 307-250g. (Table 4.1). The maximum and minimum weight of cake was recorded at Expt. 21, and 26 respectively. These experiments represented the combination of ingredients as 20%, 30gm, 60gm, 1.5gm, 1.5gm, and 30%, 30gm, 40gm, 2.5gm, 1.5gm of sucralose, fat, baking powder and water respectively. The analysis of variance table for full second order regression model (Table 4.3) indicates that the F-ratio of the model (7.22) was lower as compared with the table value of 1.94 at 5 per cent level of significance. R^2 value of model was 83 per cent. It indicates that model explained 64 per cent variability.

Table 4.2 comprises the results of linear effect and interaction of sucralose and baking ingredients on weight of cake. The findings indicate that weight of cake was significantly affected by addition of sucralose, fat, milk powder and sodium bicarbonate at 1% level of confidence. The interaction of baking powder–sodium bi carbonate was also significant. The rest of the interactions and quadratic term of model were non-significant even at 10% level of significance.

4.2 Chemical properties of Sugar free cake

4.2.1 Moisture, Protein, Carbohydrate and Fat

Chemical properties of sugar free cakes are presented in Table 4.5. The moisture, protein, carbohydrate and fat content in cake sample varied from 18.66-28.88, 6.56-10.94, 32.-56.4, and 7.4-15.8 percent. The cake sample with maximum in moisture, protein, carbohydrate and fat content were recorded in the product of experiment 18, 9, 3 and15 respectively.

The second order polynomial model results (Table 4.6) shows that levels of milk powder, baking powder, fat has linear significant effect on moisture, carbohydrate and fat content of cake respectively. The interaction of ingredients for moisture (milk powder- baking powder), protein (sucralose-sodium bicarbonate, fat-milk powder, fat-baking powder and milk powder-sodium bi carbonate), carbohydrate (milk powder-baking powder, milk powder-sodium bi carbonate and baking powder-sodium bi carbonate) and fat (milk powder-baking powder, baking powder-sodium bi carbonate) respectively were significant in at 1% level of significance.

Table 4.6 shows that quadratic term of model for moisture (sucralose, fat, milk powder, baking powder) protein (fat, milk powder),carbohydrate (milk powder-baking powder, sodium bi carbonate) were significant however rest of the terms were non-significant even at 10% level of significance.

4.2.2 Reducing sugar, Non reducing sugar and Total sugar

The results of reducing sugar, non reducing sugar and total sugar content in cake are presented in table 4.5. The results reveal that they varied from 3.62-5.55, 3.91-11 and 9.05-15.62 percent. The regression analysis of experimental results shows that F table value of Non reducing and Total sugar content was higher as compared to table value. However it was lower in case of reducing sugar content. The R value was 73, 77, and 49 percent.

The coefficients of regression model shows that, for non reducing sugar the milk powder have negative linear significant effect. Among the interactive terms of model for Non reducing sugar (sucralose-baking powder, fat-milk powder) total sugar (sucralose-baking powder, fat-milk powder, fat-baking powder) were significant at 1% level of confidence.

The quadratic effect of addition of ingredients shows that, for Non reducing sugar and total sugar the sucralose, milk

powder, baking powder and sodium bi carbonate were significant, however rest of the terms were non-significant even at 10% level of significance.

4.3 Sensory characteristics of cake

The results of sensory evaluation test of sugar free cake for various sensory attributes viz Cell, Grain, Texture, Crumb colour, flavor and Total sensory score is presented in Table 4.9, 4.10 and 4.11.

4.3.1.1 Cell score

The effect of different combination of ingredient on cell score of sugar free cake is given in Table 4.9. The sensory score for cell of cake ranges from 14.5 to 27.5. The experiment number 4 represented the lowest and experiment number 22 had a highest score for cell. These experiments had the combination of ingredients as 30%, 30 g, 60 g, 1.5g, 1.5g, and 30%, 40g, 40g, 1.5g, 0.75g of socralose, fat, baking powder and sodium bi carbonate respectively. The ANOVA Table indicates that F-ratio was significant. The F-ratio (8.16) was lower as compared to table value of 1.94. The R^2 value of perdition model was 84%.

Table 4.10 comprises the results of linear effect and interaction of sucralose and baking ingredients on cell score of cake. The cell score of cake was positively significantly affected by addition of sucralose, fat, and sodium bicarbonate at 1% level of confidence. The interaction of sucralose-milk powder, milk powder-sodium bi carbonate was significant. The sucralose-milk powder had positive significant effect. The levels of fat and milk powder have positive quadratic significant effect. The rest of the interactions and quadratic terms of model were non-significant even at 10% level of significance.

4.3.2 Grain score

The sensory score for grain score of sugar free cake was maximum (14.5) in Expt. 24 and minimum (8.5) in Expt.2. The experiments 24 and 2 represents the combination of various ingredients viz. sucralose, fat, milk powder, baking powder and sodium bi-carbonate to be 30%, 40g, ,60g, 1.5g, 1.5g and 30%, 30g, 40g, 1.5g, 0.75g, respectively. The analysis of variance table indicates that F-ratio for full second order regression model was lower than the F table value at 5 per cent level of significance. The R^2 value and standard deviation of model were found to be 52 per cent and 1.32, respectively. The model was found to be non significant adequate hence further not evaluated for linear, quadratic and interactive terms.

4.3.3 Texture

The sensory score for texture of cake ranged from 20.25 - 32.25 in Expt 1 and 8 respectively. The combination of ingredients in these experiments was sucrolase, fat, milk powder, baking powder and sodium bi carbonate to be and 20%, 30g, 40g, 1.5g, 0.75g, and 30%, 40g, 60g, 1.5g, 0.75g, respectively. The ANOVA table shows that F-ratio was highly significant. The R^2 value and standard deviation of model were found to be 82 per cent and 1.38, respectively. The model term was significant and further evaluated.

Table 4.10 comprises the results of linear effect and interaction of sucralose and baking ingredients on texture score of cake. The Texture score of cake was positively significantly affected by addition of milk powder, and sodium bicarbonate at 1% level of confidence. The interaction of fat-milk powder, fat-baking powder, milk powder-baking powder, milkpowder-sodium bicarbonate and baking powder- sodium bicarbonate was significant. The positive significant interaction between fat-milk powder levels has been observed. All other interaction were showing negative effect. The levels of sucralose have positive

quadratic significant effect. The rest of the interactions and quadratic terms of model were non-significant.

4.3.4 Crumb colour

The crumb colour score of sugar free cake varied 7.3 to 10. The minimum and maximum score represent the group of liked slightly and liked very much rating of scale. The experiment of minimum (Expt.42) and maximum sensory score (Expt.16) represented the combination of ingredients viz. sucralose, fat, baking powder and water to be 25%, 35g, 50g, 2.00g, 2.02g and 30%, 40g, 60g, 2.5g, 0.75g, respectively. The analysis of variance table shows Table value 1.94 is lower than F-ratio (2.61) at 5% level of significance. The coefficients of determination (R^2) and standard deviation of model was 64% and 0.79 respectively.

The probability value of regression model shows those linear and interactive terms of model for crumb colour were non significant. The quadratic effect of addition of sucralose, fat, milk powder and sodium bi carbonate were significant at 1% level of significance.

4.3.5 Flavour

The flavor score of sugar free cake varied 6.5 to 10. The minimum and maximum score represent the group of liked slightly and liked very much rating of scale. The experiment of minimum (Expt.13) and maximum sensory score (Expt. 11) represented the combination of ingredients viz. sucralose, fat, baking powder and water to be 20%, 30g, 60g, 2.5g, 0.75g,and 20%, 40g, 40g, 2.5g, 0.75g, respectively. The analysis of variance F-table 1.94 (Table 4.11) of model indicates that F-ratio (1.70) was non significant at 5% level of significance. The coefficients of determination (R^2) and standard deviation of model was 53% and 0.93 respectively. The model could not explain the variability so could not considered for further analysis.

4.2.1 Total sensory score

The total sensory score (overall acceptability) of sugar free cake varied 61.0-91.5. The minimum and maximum score was observed at experiment 1 and 23 respectively. The experiment of minimum (Expt.1) and maximum sensory score (Expt. 23) represented the combination of ingredients viz. sucralose, fat, milk powder, baking powder, and sodium bicarbonate to be20%,30,40,1.5,0.75 and 20%,40.60,1.5and1.5 respectively. The analysis of variance F table value 1.94 (Table 4.7) of model indicates that F-ratio (11.45) was highly significant at 5% level of significance. The coefficients of determination (R^2) and standard deviation of model was 83% and 6.90 respectively.

Coefficients of regression model presented in table 4.9 indicate that milk powder and sodium bicarbonate have contributed positive linear significant effect. However other ingredients were found not significant event at 10% level of confidence. The interaction of ingredients between sucralose-milk powder, fat-baking powder, milk powder-baking powder, fat-sodium bi carbonate and baking powder-sodium bi carbonate for total sensory score of cake were significant.

Among the quadratic terms of model levels of milk powder, and sodium bi carbonate have exhibited negative while baking powder positive significant quadratic effect. Other terms of model were found non significant.

4.3 Best fit models for responses of sugar free Cakes.

In order to predict the responses simple models are required. Hence all non significant terms of full second order polynomial model for each response of sugar free cakes were removed and regression analysis was done. The best fit empirical equations thus developed did not sacrifice the accuracy of results. The results of best fit models are presented in table 4.13, 4.14 and 4.15 A perused of table revels that F- ratio for all best fit models of sugar free cake was higher as compared to

table value. The coefficients of determination (R^2) value was reduced as compared to full second order model

Best product based on sensory quality characteristics

The highest total sensory score of product liked very much was has been considered to evaluate best product. The sensory score of attributes viz .cell, grain texture, colour and flavor taste and total score have been considered for evaluation of best quality product. The cakes sample that has received highest sensory score has been selected as best products. The product of experiment number 23 has received highest score to be 91.5 score. The combination of ingredient to prepare above product were 20%, 40g, 60g, 1.5g, 1.5g, sucralose fat, milk powder, baking powder and sodium bi carbonate respectively. It is inferred from above that best acceptable product can be developed using above level of ingredient at house hold and commercial scale.

Table 4.1 Physical property of Sugar free cake

Exp. No.	Thickness (cm)	Volume (g)	Density (%)	Weight (g)
1	4.80	786	0.33	262
2	4.90	809	0.31	257
3	4.90	840	0.32	275
4	4.80	817	0.33	273
5	5.20	750	0.37	280
6	5.50	747	0.35	266
7	5.40	753	0.37	279
8	5.70	735	0.38	282
9	5.60	759	0.33	257
10	5.80	807	0.31	251
11	6.90	791	0.35	278
12	5.90	798	0.32	260
13	6.70	739	0.38	282
14	6.50	736	0.37	278
15	6.60	739	0.39	294
16	5.50	815	0.36	300
17	5.50	740	0.35	265
18	6.40	704	0.38	273
19	6.20	728	0.40	294
20	5.80	748	0.37	280
21	7.00	643	0.47	307
22	6.90	663	0.42	284
23	6.90	657	0.45	297
24	7.30	655	0.41	296
25	6.00	739	0.33	275
26	6.10	709	0.38	250
27	6.20	739	0.36	272
28	5.50	749	0.36	270
29	7.50	672	0.42	286
30	7.00	689	0.39	275
31	7.50	679	0.43	295
32	6.10	691	0.39	270
33	7.20	710	0.40	284
34	5.80	749	0.34	261
35	6.70	703	0.38	269
36	6.00	719	0.39	283
37	4.70	799	0.34	247
38	7.00	694	0.42	297
39	5.70	782	0.34	271
40	6.30	710	0.39	280
41	5.70	779	0.35	279
42	7.50	699	0.40	280
43	5.50	745	0.37	279
44	5.50	745	0.37	279
45	5.50	745	0.37	279
46	5.50	745	0.37	279
47	5.50	745	0.37	279
48	5.50	745	0.37	279
49	5.50	745	0.37	279
50	5.50	745	0.37	279

Table 4.2 Regression coefficient of full second order model and significant term for physical properties of Sugar free cake

Co-efficient	Thickness (cm)	Volume (g/ml)	Density	Weight (g)
Constant	5.49	745.35	0.37	279.19
Linear				
β_1	-0.15	4.87	-8.374	-4.33
β_2	-0.043	6.47	2.858	4.62
β_3	0.40	-26.54	0.023	9.19
β_4	0.22	-2.20	-4.867	-1.28
β_5	0.40	-32.47	0.020	2.71
Interactive				
β1.2	-0.15	1.44	-2.500	0.84
β1.3	-0.044	2.50	-6.250	-0.16
β1.4	-0.19	4.87	0.000	-1.16
β1.5	-6.250	-300	0.000	-1.66
β2.3	-0.075	-2.25	-2.500	-1.78
β2.4	-0.056	1.87	0.000	0.094
β2.5	-0.050	-2.13	-1.250	-1.53
β3.4	-0.037	7.44	-1.250	1.72
β3.5	0.16	-3.56	2.500	-0.53
β4.5	-0.26	5.69	-7.500	-4.03
Quadratic				
β1.1	0.17	-2.42	-3.727	-0.98
β2.2	0.14	-5.70	2.279	-0.36
β3.3	0.051	0.58	1.395	-1.07
β4.4	0.078	0.49	-1.257	-0.45
β5.5	0.18	-0.75	5.112	0.25

*** Significant at 1%
** Significant at 5%
β_1 Sugar free
β_2 Fat
β_3 Milk powder
β_4 Baking powder
β_5 Sodium bicarbonate

Table 4.3 ANOVA for full second order regression model for physical properties Sugar free cake

Source	Thickness	Volume	Density	Weight
Model S.S	26.22	86356.70	0.048	6862.52
Model M.S.	1.31	4317.83	2.415	343.13
Model DF	20	20	20	20
Error S.S.	2.55	12953.30	9.042	1379.16
Error M.S.	0.088	446.670	3.118	47.560
Error DF	29	29	29	29
F ratio	14.93	9.67	7.74	7.22
F Table	1.94	1.94	1.94	1.94
R square %	91	86	84	83
Std. dev.	0.30	21.13	0.018	6.90
Mean	6.02	738.60	0.37	276.92
C.V.%	4.92	2.86	4.75	2.49

Table 4.4 ANOVA for best fit model for physical properties Sugar free cake

Source	Thickness	Volume	Density	Weight
Model S.S	25.61	81734.00	0.047	6304.83
Model M.S.	1.97	13622.33	7.782	1050.81
Model DF	13	6	6	6
Error S.S.	3.16	17576.00	0.011	1936.85
Error M.S.	0.088	408.74	2.475	45.04
Error DF	36	43	43	43
F ratio	22.44	33.33	31.44	23.33
F Table	2.00	2.32	2.32	2.32
R square %	89	82	81	76
Std. dev.	0.30	20.22	0.016	6.71
Mean	6.02	738.6	0.37	276.92
C.V.%	4.92	2.74	4.23	2.42

Table 4.5: Chemical Composition of Sugar free cake

Exp. No.	Moisture (%)	Protein (%)	Carbohydrate (%)	Fat (%)	Sugar content (%)		
					Reducing Sugar (%)	Non reducing Sugar (%)	Total Sugar (%)
1	25.95	10.50	45.00	8.90	4.54	4.92	9.46
2	24.76	8.75	45.50	9.30	5.20	5.21	10.41
3	26.87	9.63	56.40	7.55	4.09	4.96	9.05
4	21.46	8.31	47.64	8.80	4.90	8.04	12.13
5	18.66	10.06	35.52	8.50	4.16	7.00	11.16
6	21.08	6.56	40.09	10.20	4.71	5.05	9.76
7	18.88	9.63	36.48	11.70	5.00	4.32	9.32
8	22.70	7.44	47.09	12.25	4.80	7.95	12.75
9	20.30	10.94	39.70	13.30	4.31	7.15	11.46
10	22.55	8.31	39.35	10.25	4.03	6.74	10.77
11	23.09	9.19	35.50	12.00	4.62	11.00	15.62
12	20.71	8.31	38.30	13.60	4.40	8.35	12.75
13	18.93	8.75	35.83	9.05	4.09	7.37	11.46
14	24.05	7.00	34.83	10.75	5.10	6.69	11.79
15	21.77	10.50	34.32	15.80	4.23	8.65	12.88
16	24.77	8.31	35.52	10.05	4.03	5.44	9.75
17	24.25	9.63	32.66	9.55	3.96	5.80	9.76
18	28.88	10.94	47.64	10.35	4.16	6.90	11.06
19	21.52	7.44	51.26	12.50	3.62	9.67	13.29
20	26.17	8.31	51.92	13.05	3.67	8.95	12.62
21	22.31	9.19	43.54	11.40	5.10	7.92	13.02
22	22.09	10.06	41.75	10.10	4.03	9.12	13.15
23	21.70	8.75	37.50	11.25	5.55	3.91	9.46
24	23.80	7.00	38.30	13.30	5.20	8.53	13.73
25	22.17	7.44	39.70	9.65	4.38	7.86	15.24
26	20.39	10.50	34.91	10.90	4.03	10.50	14.53
27	26.80	6.56	41.45	12.70	4.62	9.58	14.20
28	25.57	7.88	37.85	12.10	4.80	8.35	13.15
29	24.59	8.31	42.63	9.85	3.73	8.06	11.79
30	20.51	9.19	47.54	8.90	3.67	8.12	11.79
31	21.63	10.50	46.02	10.95	4.23	6.54	10.77
32	21.24	10.94	44.02	10.00	4.09	5.67	9.76
33	22.32	7.44	45.50	11.25	3.84	6.24	10.08
34	21.93	7.00	43.08	11.80	3.67	6.25	9.92
35	21.44	9.19	45.00	7.40	4.23	10.83	15.06
36	23.04	10.06	40.50	12.00	3.96	10.08	14.04
37	19.81	8.31	35.52	8.90	3.67	9.77	13.44
38	21.03	10.50	37.50	12.50	5.43	7.19	12.62
39	21.61	7.44	33.75	12.80	4.16	7.63	11.79
40	21.61	7.00	34.03	10.95	5.00	5.16	10.16
41	22.78	8.75	34.61	10.95	4.71	6.99	11.16
42	24.06	7.44	35.84	12.00	5.10	5.67	10.77
43	26.15	7.88	50.62	11.15	4.71	10.35	15.06
44	26.15	7.88	50.62	11.15	4.71	10.35	15.06
45	26.15	7.88	50.62	11.15	4.71	10.35	15.06
46	26.15	7.88	50.62	11.15	4.71	10.35	15.06
47	26.15	7.88	50.62	11.15	4.71	10.35	15.06
48	26.15	7.88	50.62	11.15	4.71	10.35	15.06
49	26.15	7.88	50.62	11.15	4.71	10.35	15.06
50	26.15	7.88	50.62	11.15	4.71	10.35	15.06

Table 4.6 Regression coefficient of full second order model and significant term for chemical attributes of Sugar free cake

Co-efficient	Moisture	Protein	Carbohydrate	Fat	Reducing	Non-reducing	Total Sugar
Constant	26.2	7.96	50.82	11.13	4.71	10.27	15
Linear							
β_1	0.24	-0.24	0.30	0.013	4.287	0.11	0.036
β_2	0.25	-0.12	0.52	0.87	0.046	0.086	0.051
β_3	-0.69	0.11	-0.90	0.19	0.15	-0.46	-0.35
β_4	-0.28	-0.014	-1.62	0.16	-0.054	0.28	0.32
β_5	0.46	-0.062	0.80	0.16	-0.056	0.31	0.37
Interactive							
$\beta_{1.2}$	-0.093	-0.068	-0.48	-0.058	-0.023	0.013	0.067
$\beta_{1.3}$	0.38	-0.29	0.50	-0.16	-0.047	0.022	0.10
$\beta_{1.4}$	-0.32	0.18	-0.76	-0.40	-0.022	-0.55	-0.63
$\beta_{1.5}$	-0.12	0.73	-0.013	0.077	-0.11	0.27	0.080
$\beta_{2.3}$	0.042	0.48	-1.20	0.20	0.076	-0.69	-0.49
$\beta_{2.4}$	0.53	0.34	-1.14	0.077	0.022	-0.10	-0.14
$\beta_{2.5}$	-0.023	-0.26	0.079	0.11	0.087	-0.36	-0.35
$\beta_{3.4}$	0.77	0.29	2.24	-0.56	-0.20	-0.39	-0.70
$\beta_{3.5}$	-0.095	0.34	1.61	-0.30	0.073	-0.18	-0.24
$\beta_{4.5}$	-0.11	-0.013	1.56	-0.75	0.027	-0.31	-0.23
Quadratic							
$\beta_{1.1}$	-0.67	-0.042	-0.94	0.046	-0.17	-0.79	-0.95
$\beta_{2.2}$	-0.65	0.38	-1.22	-0.28	-0.11	-0.05	-0.14
$\beta_{3.3}$	-0.97	0.34	-2.32	-0.100	-0.029	-0.4	-0.41
$\beta_{4.4}$	-0.76	-0.042	-2.78	0.11	-0.024	-0.77	-0.78
$\beta_{5.5}$	-0.44	0.11	-2.55	0.037	0.034	-0.78	-0.78

*** Significant at 1%,** Significant at 5%

β_1 Sugar free

β_2 Fat

β_3 Milk powder

β_4 Baking powder

β_5 Sodium bicarbonate

Table 4.7 ANOVA for full second order regression model for chemical composition Sugar free cake

Source	Moisture	Protein	Carbohydrate	Fat	Reducing Sugar	Non- Reducing Sugar	Total Sugar
Model S.S	173.71	58.93	1510.20	81.71	6.09	142.62	155.85
Model MS.	8.69	2.95	75.51	4.09	0.30	7.13	7.79
Model DF.	20	20	20	20	20	20	20
Error SS.	125.25	18.48	475.26	46.35	6.28	52.26	44.92
Error MS.	4.32	0.64	16.39	1.60	0.22	1.80	1.55
Error DF.	29	29	29	29	29	29	29
F ratio	2.01	4.62	4.61	2.56	1.41	3.96	5.03
F Table	1.94	1.94	1.94	1.94	1.94	1.94	1.94
R Square %	58	76	76	63	49	73	77
Std. dev.	2.08	0.80	4.05	1.26	0.47	1.34	1.24
Mean	23.18	8.62	42.32	10.97	4.45	7.86	12.35
C.V.%	8.97	9.26	9.57	11.53	10.46	17.08	10.08

Table 4.8 ANOVA for best fit model for chemical composition Sugar free cake

Source	Moisture	Protein	Carbohydrate	Fat	Reducing Sugar	Non- Reducing Sugar	Total Sugar
Model. S.S	135.10	56.72	143.79	74.22	4.63	126.52	149.90
Model M.S.	15.01	4.05	102.49	8.25	0.66	11.50	11.53
Model DF.	9	14	14	9	7	11	13
Error SS.	163.85	20.69	550.66	53.84	7.74	68.36	50.88
Error MS.	4.10	0.59	15.73	1.35	0.18	1.80	1.41
Error DF.	40	35	35	40	42	38	36
F ratio	3.66	6.85	6.51	6.13	3.59	6.39	8.16
F Table	2.12	1.99	1.99	2.12	2.24	2.05	2.00
R square %	45	73	72	57	37	64	74
Std. dev.	2.02	0.77	3.97	1.16	0.43	1.34	1.19
Mean	23.18	8.62	42.32	10.97	4.45	7.86	12.53
C.V.%	8.73	8.92	9.37	10.58	9.65	17.07	9.63

Table 4.9 Sensory evaluation score of Sugar free cake

Exp. No.	Cell 30 point	Grain 16 point	Texture 34 point	Crumb coloure 10 point	Flavour 10 point	Total score 100 point
1	14.75	9.50	20.25	9.00	7.50	61.00
2	15.75	8.50	23.00	7.50	7.50	62.50
3	18.00	14.50	23.75	7.50	5.75	69.50
4	14.50	11.00	23.75	5.50	7.50	62.25
5	21.25	12.50	26.00	8.50	9.00	77.25
6	21.25	13.00	27.50	7.50	9.50	78.75
7	20.00	14.50	27.25	8.50	9.25	79.50
8	21.25	14.00	32.25	8.00	9.25	78.75
9	22.75	11.00	26.75	8.50	10.00	79.00
10	15.50	14.50	25.50	7.50	10.00	73.00
11	20.25	14.50	25.50	7.50	10.00	77.75
12	16.25	11.00	24.75	8.00	10.00	70.00
13	22.00	14.50	27.75	8.50	6.50	76.75
14	24.00	13.00	28.25	8.00	7.50	79.75
15	19.75	11.50	29.75	8.00	6.75	75.75
16	23.00	14.50	26.50	10.00	10.00	84.00
17	25.00	13.00	29.25	9.00	10.00	86.25
18	19.00	12.50	29.50	9.00	10.00	80.00
19	24.50	13.00	30.50	8.00	10.00	86.00
20	23.50	13.00	31.00	9.00	10.00	89.00
21	22.00	10.50	30.50	8.00	10.00	81.00
22	27.50	12.00	29.00	9.00	10.00	91.50
23	22.50	14.50	30.00	8.50	10.00	85.50
24	25.00	14.50	33.00	8.50	10.00	91.00
25	23.00	11.50	30.50	8.50	10.00	84.25
26	25.00	14.50	29.50	7.50	10.00	86.50
27	25.00	14.50	26.00	8.50	8.75	82.75
28	21.00	10.50	24.75	8.75	9.00	74.00
29	22.25	13.00	26.50	8.75	9.25	79.75
30	24.75	14.50	25.50	8.50	8.75	82.00
31	25.50	11.50	25.25	8.25	8.75	79.25
32	21.75	12.00	30.00	8.00	10.00	81.75
33	25.50	11.00	30.00	7.50	10.00	84.00
34	19.50	11.00	29.50	7.00	10.00	77.00
35	21.00	11.00	26.50	8.00	10.00	76.50
36	22.00	11.50	28.50	7.50	10.00	79.50
37	16.75	12.50	24.75	8.00	10.00	72.00
38	20.50	12.50	27.50	8.00	10.00	78.50
39	25.50	12.00	27.50	9.00	10.00	88.50
40	25.75	12.50	30.50	7.50	10.00	86.25
41	16.50	11.00	24.50	7.50	10.00	69.50
42	27.33	10.66	30.66	7.30	10.00	85.00
43	23.75	12.00	27.00	9.25	9.50	81.50
44	23.75	12.00	27.00	9.25	9.50	81.50
45	23.75	12.00	27.00	9.25	9.50	81.50
46	23.75	12.00	27.00	9.25	9.50	81.50
47	23.75	12.00	27.00	9.25	9.50	81.50
48	23.75	12.00	27.00	9.25	9.50	81.50
49	23.75	12.00	27.00	9.25	9.50	81.50
50	23.75	12.00	27.00	9.25	9.50	81.50

Table 4.10 Regression coefficient of full second order model and significant term for sensory attributes of Sugar free cake

Coefficient	Cell	Grain	Texture	Crumb colour	Flavour	Total Score
Constant	23.65	12.14	26.95	9.29	9.39	81.38
Linear						
β_1	-0.55	-0.023	0.16	-0.10	0.17	-0.30
β_2	-0.037	0.28	0.31	-0.091	-0.012	0.34
β_3	1.13	0.30	0.86	0.12	-0.035	2.17
β_4	0.38	0.17	-0.15	-0.042	0.000	0.027
β_5	2.14	0.051	1.31	0.17	0.43	4.43
Interactive						
$\beta_{1.2}$	-0.28	-0.47	0.24	0.16	0.17	-0.44
$\beta_{1.3}$	1.13	0.34	0.30	0.13	0.11	1.94
$\beta_{1.4}$	-0.28	0.19	-0.46	0.086	0.094	-0.38
$\beta_{1.5}$	0.16	0.16	-0.023	0.15	-0.17	0.58
$\beta_{2.3}$	-0.27	-0.094	0.54	0.15	0.23	0.31
$\beta_{2.4}$	-0.30	-0.75	-0.76	0.16	0.094	-1.22
$\beta_{2.5}$	0.14	-0.22	-0.26	0.039	-0.078	-0.36
$\beta_{3.4}$	-0.36	-0.25	-0.57	0.039	-0.59	-1.72
$\beta_{3.5}$	-0.92	-0.41	-1.04	-0.21	-0.016	-2.27
$\beta_{4.5}$	-0.55	-0.25	-1.12	-0.20	-0.34	-2.70
Quadratic						
$\beta_{1.1}$	-0.31	-0.047	0.44	-0.31	-0.013	-0.29
$\beta_{2.2}$	-0.49	-2.961	0.041	-0.23	-0.013	-0.73
$\beta_{3.3}$	-0.99	0.22	-0.20	-0.18	-0.013	-1.22
$\beta_{4.4}$	0.24	0.17	0.31	-0.14	-0.013	0.93
$\beta_{5.5}$	-0.41	-0.077	0.056	-0.29	-0.013	-0.86

*** Significant at 1%
** Significant at 5%
β_1 Sugar free
β_2 Fat
β_3 Milk powder
β_4 Baking Powder
β_5 Sodium bicarbonate

Table 4.11 ANOVA for full second order regression model for sensory properties Sugar free cake

Source	Cell	Grain	Texture	Crumb colour	Flavour	Total Score
Model S.S	444.27	55.59	258.59	20.35	29.15	1962.33
Model M.S.	22.21	2.78	12.93	1.02	1.46	98.12
Model DF	20	20	20	20	20	20
Error S.S.	78.92	50.25	55.02	11.30	24.91	248.61
Error MS	2.72	1.73	1.90	0.39	0.86	8.57
Error DF	29	29	29	29	29	29
F ratio	8.16	1.60	6.82	2.61	1.70	11.45
F Table	1.94	1.94	1.94	1.94	1.94	1.94
R square %	84	52	82	64	53	88
Std. dev.	1.65	1.32	1.38	0.62	0.93	2.93
Mean	21.96	12.37	27.50	8.30	9.33	79.50
C.V.%	7.51	10.64	5.01	7.52	9.93	3.68

Table 4.12. ANOVA for best fit regression model of sensory properties of Sugar free cake.

Source	Cell	Texture	Crumb colour	Total Score
Model. S.S	418.71	248.76	13.97	1929.12
Model M.S.	38.06	19.14	1.55	137.79
Model DF	11	13	9	14
Error S.S.	104.48	64.85	17.67	281.81
Error MS	2.75	1.80	0.44	8.05
Error DF	38	36	40	35
F ratio	13.84	10.62	3.51	17.11
F Table	2.05	2.00	2.12	1.99
R square %	80	79	44	87
Std. dev.	1.66	1.34	0.66	2.84
Mean	21.96	27.50	8.30	79.50
C.V.%	7.55	4.88	8.01	3.57

Table 4.14 Best fit models of physical for various responses of Sugar free cake

Thickens	Y_1	$5.49 + 0.40X_5 + 0.40X_3 - 0.26X_4X_5 + 0.22X_4 + 0.14X^2_5 - 0.19X_1X_4 + 0.14X^2_1 - 0.15X_1 + 0.12X^2_2 + 0.16X_3X_5 - 0.15X_1X_2 + 0.071X^2_4$
Volume	Y_2	$745.35 - 32.47X_5 - 26.54X_3 + 6.47X_2 + 7.44X_3X_4 - 5.50X^2_2$
Density	Y_3	$0.37 + 0.023X_3 + 0.020X_5 - 8.37X_1 - 7.50X_4X_5 - 6.25X_1X_3$
Weight	Y_4	$279.19 + 9.19X_3 + 4.62X_2 - 4.33X_1 - 4.03X_4X_5 + 2.71X_5$

Table 4.13 Best fit models of Chemical for various responses of Sugar free cake

Moisture	Y_5	$26.20 - 0.73X^2_3 - 0.69X_3 - 0.58X^2_4 + 0.77X_3X_4 - 0.54X^2_1 - 0.59X^2_2$
Protein	Y_6	$7.96 + 0.73X_1X_5 + 0.48X_2X_3 + 0.35X^2_2 + 0.34X^2_3 + 0.34X_2X_4 + 0.34X_3X_5 + 0.29X_3X_4 - 0.29X_1X_3 - 0.24X_1 - 0.26X_2X_5$
Carbohydrate	Y_7	$50.82 - 2.12X_4^2 - 2.08X^2_5 + 2.07X^2_3 + 2.24X_3X_4 - 1.62X_4 + 1.61X_3X_5 + 1.56X_4X_5 - 1.09X^2_2 - 0.94X_1^2 - 1.20X_2X_3$
Fat	Y_8	$11.13 + 0.87X_2 - 0.75X_4X_5 - 0.56X_3X_4 - 0.40X_1X_4 - 0.29X^2_2$
Reducing Sugar	Y_9	$4.71 - 0.16X_1^2 - 0.20X_3X_4 + 0.15X_3 - 0.11X^2_2$
Non Reducing Sugar	Y_{10}	$10.27 - 0.61X^2_1 - 0.65X^2_5 - 0.72X^2_4 - 0.69X_2X_3 - 0.55X_1X_4 - 0.46X_3 - 0.39X^2_3$
Total Sugar	Y_{11}	$15.00 - 0.75X^2_1 - 0.64X^2_5 - 0.71X^2_4 - 0.70X_3X_4 - 0.63X_1X_4 - 0.39X^2_3 - 0.49X_2X_3 + 0.37X_5 - 0.35X_3 + 0.32X_4 - 0.35X_2X_5$

Table 4.15 Best fit Models of sensory for various response of Sugar free cake

Cell	Y_{12}	$23.65 + 2.14X_5 + 1.13X_3 -0.90X^2_3+1.13X_1X_3-0.92X_3X_5-0.55X_1-0.44X^2_2-0.55X_4X_5-0.40X^2_5$
Texture	Y_{13}	$26.95 -1.31X_5 -1.12X_4X_5 -1.04X_3X_5 + 0.86X_3 -0.76X_2X_4 -0.57X_3X_4+0.42X^2_1-0.54X_2X_3-0.46X_1X_4+0.32X^2_4$
Crumb colour	Y_{14}	$9.29-0.24X^2_1-0.23X^2_5 -0.19X^2_2 -0.16X^2_3 -0.21X_3X_5$
Total score	Y_{15}	$81.38-4.43X_5-2.70X_4X_5+2.17X_3-2.27X_3X_5+1.94X_1X_3-1.72X_3X_4+1.22X^2_4 -1.02X^2_3 -1.22X_2X_4-0.74X^2_5 -0.69X^2_2$

DISCUSSION

Intensified health problems of the society resulted in a change of human attitude to the quality of consumed products. Within the last few years the interest in “safe food” has increased significantly. In many diets the contents of sugar, honey, jam, ice cream and sweet cakes were reduced to minimum (Baik et al., 2000; Booth et al., 2000; Brown et al., 1996; Mojet et al., 2002). Utilization of Sugar free ingredients in food products is an area of current interest because of nutritional awareness of consumer and changing demographics. The nutritive values of sugar free baked products are very high. Cakes thus, made can be used effectively for feeding the diabetic and diseased peoples. Cakes can be easily fortified with sugar free and fat free substances to produce convenient food of high quality. This chapter deals with the justification of the findings obtained in the experiments related to development of sugar free cake. The results have been explained with the help of reported values of various parameters given by different researchers and they are discussed as under.

5.1 Physical properties of Sugar free cake

5.1.1 Thickness

The effect of ingredients level on thickness (Y_1) of sugar free cakes shows, that thickness of cake was positively significantly affected at linear and quadratic level by addition of baking ingredients viz Sodium bicarbonate, Milk powder, Baking powder and sucralase. The interaction of ingredients viz baking powder-sodium bi carbonated, sucrolose–baking powder, milk powder–sodium bi carbonate and sucrolose-fat also significantly contributed for thickness of cake.

The increases in thickness of sugar free cake might be due to the fact that sodium bi carbonate, baking powder acts as chemical leavening agent. The carbon dioxide, ammonia gas and steam produced during baking process increase the thickness and crispiness of cake. Finney et al (1950) and Patel and Venketswarao (1996) also reported the similar findings. The functional properties of milk protein also contributed increase in thickness of cake. After removal of non significant terms of model the following best-fit model for thickness of sugar free cake can be developed as under.

$$Y_1 = 5.49 + 0.40X_5 + 0.40X_3 - 0.26X_4X_5 + 0.22X_4 + 0.14X^2_5 - 0.19X_1X_4 + 0.14X^2_1 - 0.15X_1 + 0.12X^2_2 + 0.16X_3X_5 - 0.15X_1X_2 + 0.071X^2_4$$

5.1.2 Volume

The effect of Sodium bicarbonate, Milk powder, shows negative linear significant effect, However milk powder contribute positive significant effect at 1% level of confidence. The interaction between milk powder-baking powder and quadratic effect of fat also shows significant effect on volume (Y_2) of cake. The effect of increase in total volume of cake is due to the production of carbon dioxide gas. The milk protein of milk powder and fat causes emulsification and plasticizing properties to cake dough which help to increase in total volume of cake while baking. The same can be seen from photograph of cake prepared by high level of fat and baking powder. The present findings of sugar free cake could be substantiated with the research work of Shukla (1997), Kamaliya and kamaliya (2001). The best-fit equation for volume of sugar free cake is as under.

$$Y_2 = 745.35 - 32.47X_5 - 26.54X_3 + 6.47X_2 + 7.44X_3X_4 - 5.50X^2_2$$

5.1.3 Density

The density (Y_3) of cake is a ratio of weight and volume of cake. It was significantly linearly affected by addition of baking ingredients viz sucralase, Milk powder and Sodium bicarbonate. The interaction of baking powder–sodium bi carbonate also shows significant effect on increase in density. Similar to findings of addition of baking ingredients and sodium bi carbonate, ammonium bicarbonate on increase in volume of baked product have been reported by Finney et al (1950) and Patel and Venketswarao (1996). The best-fit equation for density of sugar free cake is given below.

$$Y_3 = 0.37 + 0.023X_3 + 0.020X_5 - 8.37X_1 - 7.50X_4X_5 - 6.25X_1X_3$$

5.1.4 Weight

The weight (Y_4) of sugar free cake varied from 250g–307g. The weight of cake was significantly affected by addition of sucralose, fat, milk powder and sodium bicarbonate. The interaction of baking powder–sodium bi carbonate was also significant. The increase in weight of cake is due to additive effect of ingredients. However the decrease in weight is due to loss of moisture after baking. The best-fit equation for weight of sugar free cake is given below.

$$Y_4 = 279.19 + 9.19X_3 + 4.62X_2 - 4.33X_1 - 4.03X_4X_5 + 2.71X_5$$

5.2 Chemical composition of Sugar free cake

5.2.1 Moisture, Protein, Carbohydrate and Fat

The moisture, protein, carbohydrate and fat content in cake sample varied from 18.66-28.88, 6.56-10.94, 32-56.4and7.4-15.8 percent. The wheat flour contains low protein and fat content. The nutritive value of prepared product (cake) is increased due to the addition of milk solids, baking powder and fat. The interactions which have shown significant effect are due to the additive effect of ingredients itself. Similar findings of increase in nutritive value have been reported by Kamaliya and Kamaliya (2001).

The best-fit equation for Moisture (Y_5), Protein (Y_6), Carbohydrate (Y_7), and Fat (Y_8), of sugar free cake is given below

$$Y_5 = 26.20 - 0.73X^2_3 - 0.69X_3 - 0.58X^2_4 + 0.77X_3X_4 - 0.54X^2_1 - 0.59X^2_2$$

$$Y_6 = 7.96 + 0.73X_1X_5 + 0.48X_2X_3 + 0.35X^2_2 + 0.34X^2_3 + 0.34X_2X_4 + 0.34X_3X_5 + 0.29X_3X_4 - 0.29X_1X_3 - 0.24X_1 - 0.26X_2X_5$$

$$Y_7 = 50.82 - 2.12X_4^2 - 2.08X^2_5 + 2.07X^2_3 + 2.24X_3X_4 - 1.62X_4 + 1.61X_3X_5 + 1.56X_4X_5 - 1.09X^2_2 - 0.94X_1^2 - 1.20X_2X_3$$

$$Y_8 = 11.13 + 0.87X_2 - 0.75X_4X_5 - 0.56X_3X_4 - 0.40X_1X_4 - 0.29X^2_2$$

5.2.2 Reducing sugar, Non reducing sugar and Total sugar

The reducing sugar (Y_9), non reducing sugar (Y_{10}) and total sugar (Y_{11}) content in cake varied from 3.62-5.55, 3.91-11 and 9.05-15.62 percent. The best fit model analysis of reducing sugar content of cake of various experiments shows that linear, quadratic effect milk powder indicated positive significant effect. The interaction of fat –baking powder was also positively significant. The best-fit equation for reducing sugar is as under.

$$Y_9 = 4.71 - 0.16X_1^2 - 0.20X_3X_4 + 0.15X_3 - 0.11X^2_2$$

The baking ingredient milk powder has negative linear significant effect on non reducing sugar content of cake. The negative significant interaction between sucralose-baking powders, fat-milk powder for Non reducing sugar have been observed. In case of total sugar the interaction among sucralose-baking powder, fat-milk powder, fat-baking powder also exhibited negative significant effect. The negative linear effect and interaction is attributed due to the fact of reduction of level of table sugar as an ingredient of cake recipe. The present findings can be supported with reported literature of Kulp, Lorenz, and Stone, (1991) Ngo and Taranto, (1986) Shukla, (1995) Spies and Hoseney, (1982). The best-fit equation for reducing, non-reducing sugar and total sugar content of sugar free cake is as under.

Y_{10}= 10.27 - 0.61X^2_1 - 0.65X^2_5 - 0.72X^2_4 - 0.69X_2X_3 - 0.55X_1X_4 - 0.46X_3 - 0.39X^2_3

Y_{11}= 15.00 - 0.75X^2_1 - 0.64X^2_5 - 0.71X^2_4 - 0.70X_3X_4 - 0.63X_1X_4 - 0.39X^2_3 - 0.49X_2X_3 + 0.37X_5 - 0.35X_3 + 0.32X_4 - 0.35X_2X_5

5.3 Sensory attributes of sugar free cake

The products prepared from experiments of different sets of combination of ingredients were evaluated for sensory quality attributes viz cell, grain, flavor, colour, and Texture score. The total score of all attributes was also calculated. The effect of sucralose and baking ingredients on sensory quality attributes of sugar free cake are presented through Fig 21 to 30 and discussed as under.

5.3.1 Cell

The sensory score for cell of cake ranges from 14.5 to 27.5. The positive significant effect of sucralose, fat, and sodium bicarbonate was observed. The positive interaction between sucralose-milkpowder, while negative in milk powder-sodium bicarbonate, baking powder-sodium bicarbonate was observed. The substantial addition of fat and milk powder was also significant. The significant linear and interactive effect of sucralose and milk powder on cell score of sugar free cake is might be due to the fact that milk protein help to form thin film that retain the gas on cell. Thus more number of cells are produced due to increasing level of milk powder. The present findings are in conformity with the reported results of Frye and Setser (1991), Hess and Setser (1983) who proposed that sugar substitutes alone or their combinations at levels of above 25 % resulted in a decrease in the quality and acceptability of cakes. The best-fit equation for cell score is as under.

Y_{12} = 23.65 + 2.14X_5 + 1.13X_3 -0.90X^2_3+1.13X_1X_3-0.92X_3X_5-0.55X_1-0.44X^2_2-0.55X_4X_5-0.40X^2_5

5.2.2 and 5.2.3 Grain and Flavour sensory Score

The sensory score for grain and flavor of sugar free cake varied from 8.5-14, 6.5-10. The sensory evaluation panelist informed that baking ingredients could not contribute to grain score of cake. This effect is might be due to non carbohydrate nature of sucralose. The fitted model could explain 52 and 53 percent variability. Frye and Setser, (1991) and Altschul, (1993) also reported the similar results.

5.2.4 Texture

The levels milk powder and sodium bicarbonate have shown significant effect on textural sensory score of sugar free cake. The levels of sucralose, alone were not significant. This is might be due to non sugar nature of sucralose. Frye and Setser, (1991) and Altschul, (1993) also reported the similar results. The interaction of fat-milk powder, fat-baking powder, milk powder-baking powder, milk powder-sodium bicarbonate and baking powder- sodium bicarbonate was significant. This effect has been observed due to functional properties of milk protein and gas production by leavening agents. The similar findings are also reported by Berglund and Hertsgaard (1986) Arora *et al.* (2009) Baeva, Panchev, and Terzieva (2000) Frye and Setser (1991) in various type of products made from sugar free substances. The present findings are also in conformity with reported value of Kamaliya and Kamaliya (2001), Shukla (1997) and Arora *et al.* (2007). The best-fit model for Texture score of cake is as under.

$$Y_{13} = 26.95 - 1.31X_5 - 1.12X_4X_5 - 1.04X_3X_5 + 0.86X_3 - 0.76X_2X_4 - 0.57X_3X_4 + 0.42X^2_1 - 0.54X_2X_3 - 0.46X_1X_4 + 0.32X^2_4$$

5.2.5 Crumb Colour

The sensory score for crumb colour of cake ranges from 7.3 to 10 score. The lowest and highest sensory score indicates the liked slightly and liked very much group. The quadratic effect

of addition of sucralose, fat, milk powder and sodium bi carbonate were significant for crumb colour. However, the linear and interactive effect of baking ingredients was non significant for crumb colour score of sugar free cake. This might be due to the fact that sucrolose being a non-sugar substance could not impart non-enzymatic browning and golden brown colour to cake. The findings of present investigation can be substantiated with the reports of Kamaliya and kamaliya (2001), the best fit model for crumb colour score of cake is as under.

$$Y_{14} = 9.29-0.24X^2_1-0.23X^2_5-0.19X^2_2-0.16X^2_3-0.21X_3X_5$$

5.2.6 Total Sensory score

The total score sensory score of cake is generally considered as summation of cell, grain, texture, crumb colour, flavor, sensory score. In the present investigation score obtained for each attribute has been combined. The total score of cake varied 61 to 91.5. The minimum and maximum score represent the group of liked slightly and liked very much rating of scale. The fitted model also explains 88% variability. The findings suggest that simple effect of milk powder and sodium bicarbonate positively significant. The interaction between levels of sucralose-milk powder, fat-baking powder, milk powder-baking powder, fat-sodium bi carbonate and baking powder-sodium bi carbonate for total sensory score of cake were significant. The findings explain that additive effect of milk powder and sodium bi carbonate ingredients improves the quality of sugar free cakes. The present findings can be supported by reported results of Berglund and Hertsgaard (1986), Arora *et al.* (2009), Baeva, Panchev, and Terzieva (2000), Frye and Setser (1991), Hess and Setser (1983) The best-fit model for taste score of cake is as under.

$$Y_{15}= 81.38-4.43X_5-2.70X_4X_5+2.17X_3-2.27X_3X_5+1.94X_1X_3-1.72X_3X_4+1.22X^2_4 - 1.02X^2_3-1.22X_2X_4-0.74X^2_5-0.69X^2_2$$

In a nutshell it is deduced from the findings of present investigation and their justification that sucrolase in combination with other ingredients like Milk powder, baking powder fat and sodium bicarbonate can be successfully utilized for cake preparation without sacrificing the quality of cake. The sucralose as sugar free cake ingredient has great potential for value addition in cake industry. The standardized value of sucrolose and ingredients can be successfully translated at commercial scale for domestic and commercial application.

SUMMARY, CONCLUSION AND SUGGESTION FOR FURTHER WORK

Summary

Intensified health problems of the society resulted in a change of human attitude to the quality of consumed products. Within the last few years the interest in “safe food” has increased significantly. In many diets the contents of sugar, honey, jam, ice cream and sweet cakes were reduced to minimum. Utilization of Sugar free ingredients in food products is an area of current interest because of nutritional awareness of consumer and changing demographics. The nutritive values of sugar free baked products are very high. Cakes thus, made can be used effectively for feeding the diabetic and diseased peoples. Cakes can be easily fortified with sugar free and fat free substances to produce convenient food of high quality. Sucrolase a non sugar sweetener provides about 600 times of sucrose sweetness with no unpleasant residual flavour, non- caloric, non- cariogenic and proven as safe for human consumption. The replacement of sucrose using sugar substitute sucralose may cause deviation in physical properties and sensory quality attributes of cakes. In the light of above fact the present investigation entitled “Optimization of levels of baking ingredients for development of sugar free cake using sucrolase” has been undertaken. The findings of experiments are surmised as under.

[1] The diameter (13.8cm), thickness, volume, weight, density of sugar free cake varied from 4.7-7.5cm, 643 to 840 cc/g, 307-250g, 0.31-0.43 g/cc among product of all experiment.

[2] The moisture, protein, carbohydrate and fat content in cake sample varied from 18.66-28.88, 6.56-10.94, 32.-56.4, and 7.4-15.8 percent.

[3] The results of reducing sugar, non reducing sugar and total sugar content in cake varied from 3.62-5.55, 3.91-11 and 9.05-15.62 percent.

[4] The results of sensory evaluation test of sugar free cake for various sensory attributes were found to be, cell (14.5 to 27.5), Grain (8.5 -14.5) Texture (20.25 - 32.25), Crumb (7.3 to 10), colour,(6.5 to 10), Total sensory score 61.0-91.5 respectively

[5] The results of the effect of different levels of ingredients on various responses of sugar free cake, indicated that the ingredient level have linear and quadratic significant effect. The interactions were also significant for taste and overall acceptability response of the cake.

[6] The best fit predicted models were also developed for various responses, which could be utilized for preparation of an acceptable sugar free cake.

6.1 Conclusion

It could be concluded that sucrolase along with other baking ingredients can be utilized for sugar free cake preparations. The best quality acceptable sugar free cake can be made by using the formulation of 20%, 40g, 60g, 1.5g, 1.5g, sucralose fat, milk powder, baking powder and sodium bi carbonate respectively.

6.2 Suggestion for further work

(a) To study packaging and storage stability characteristics requirements of sugar free cake.

(b) To study various other non-sugar sweeteners such as aspartame and stevia for cake preparation.

(c) To study the use of fat free baking ingredients in combination with sucrolase for development of low calorie bakery product.

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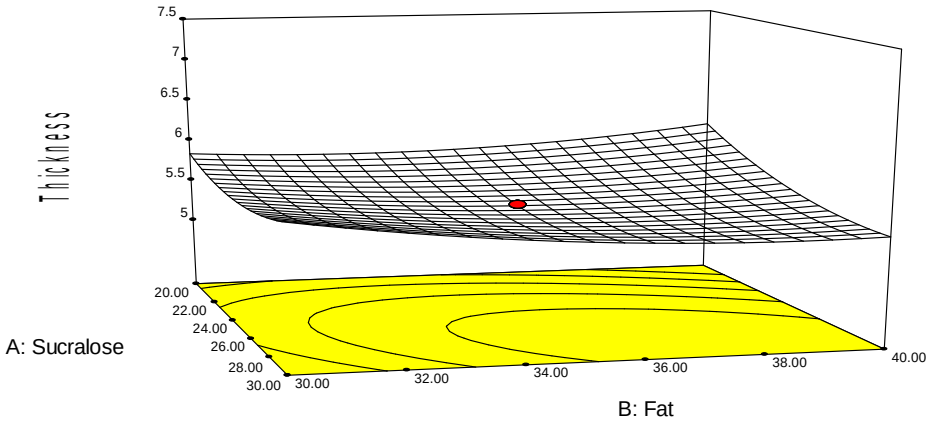


Fig 1 Effect of Sucralose and Fat on thickness of cake

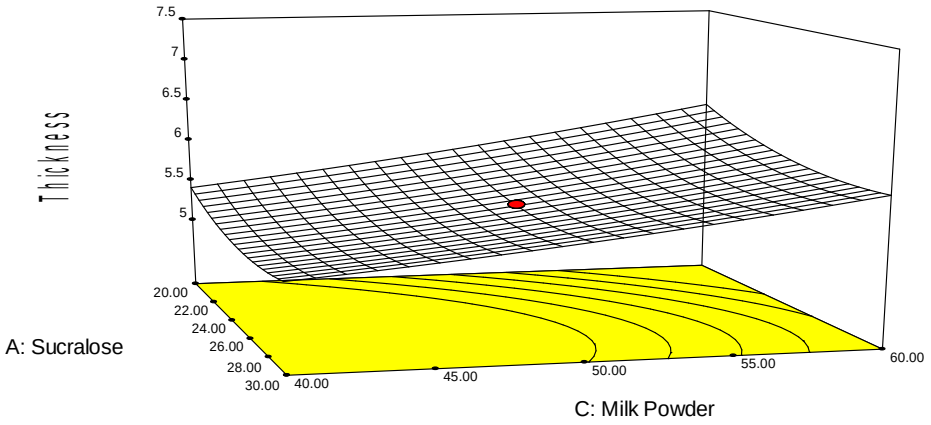


Fig 2 Effect of Sucralose and Milkpowder on thickness of cake

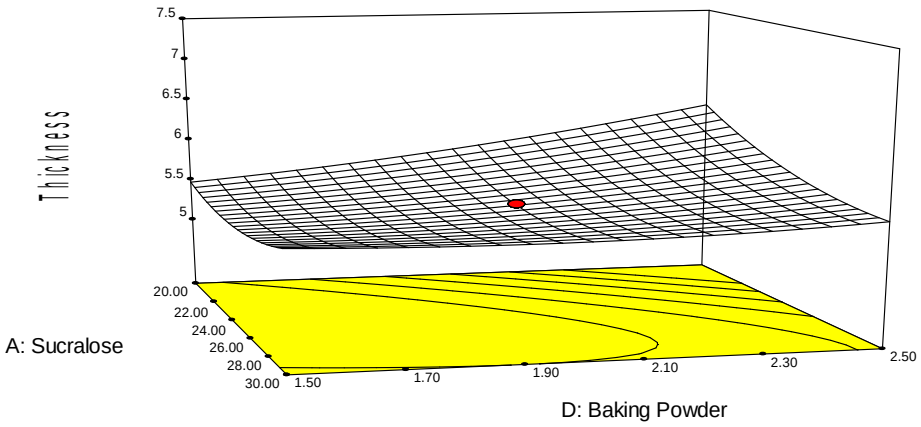


Fig 3 Effect of Sucralose and Baking powder on thickness of cake

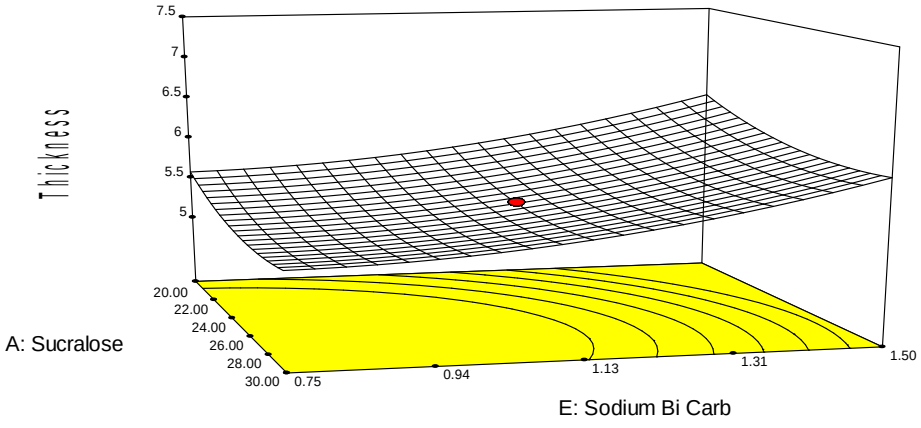


Fig 4 Effect of Sucralose and Sodiumbicarbonateon thickness of cake

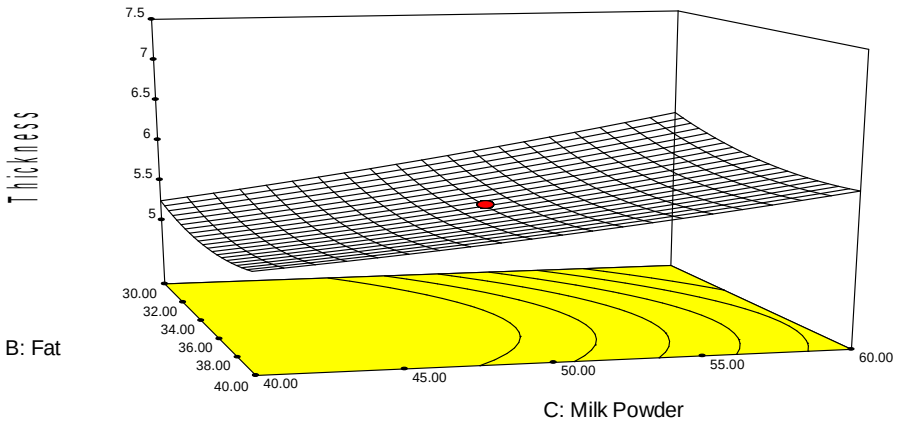
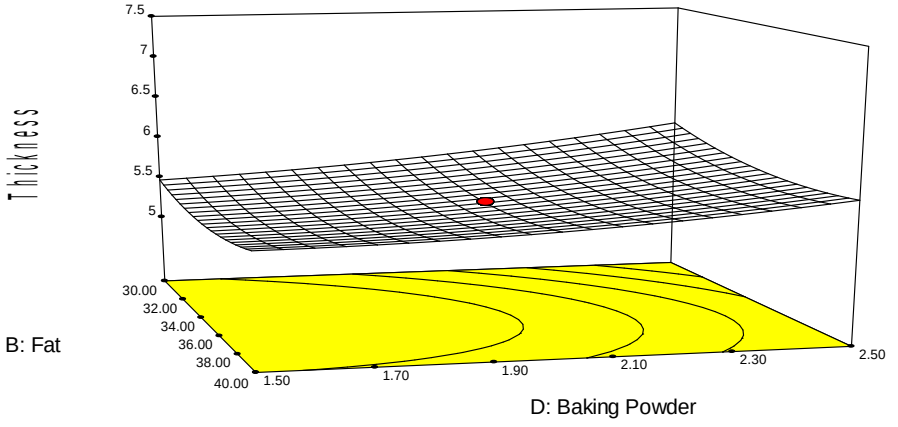


Fig 5 Effect of Fat and Milk powder thickness of cake



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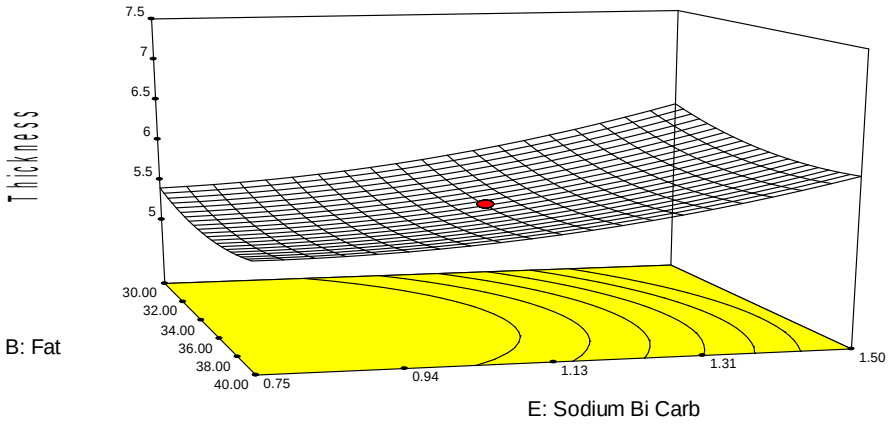

Fig 7 Effect of Fat and Sodium bicarbonate on thickness of cake

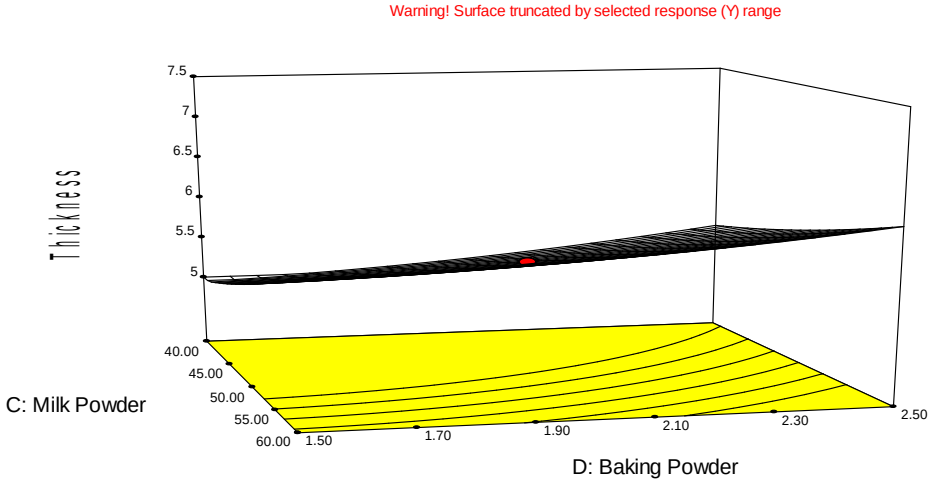

Fig 8 Effect of Milk powder and Baking powder on thickness of cake

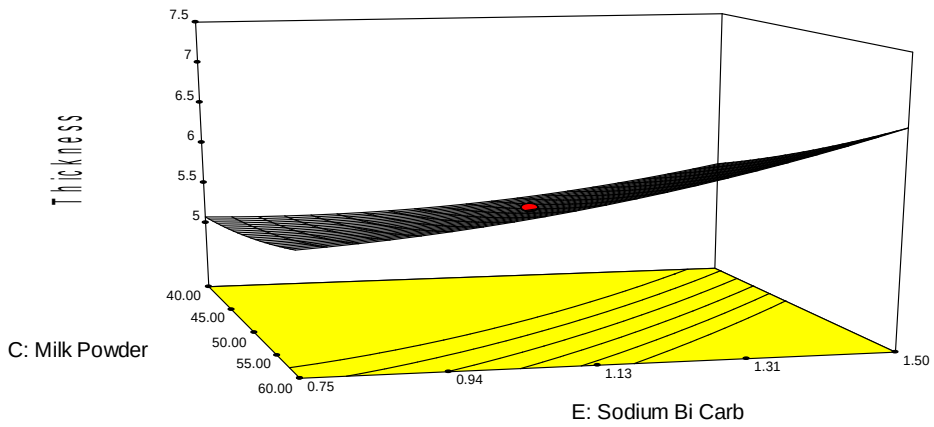

Fig 9 Effect of Milk powder and Sodium bicarbonate on thickness of cake

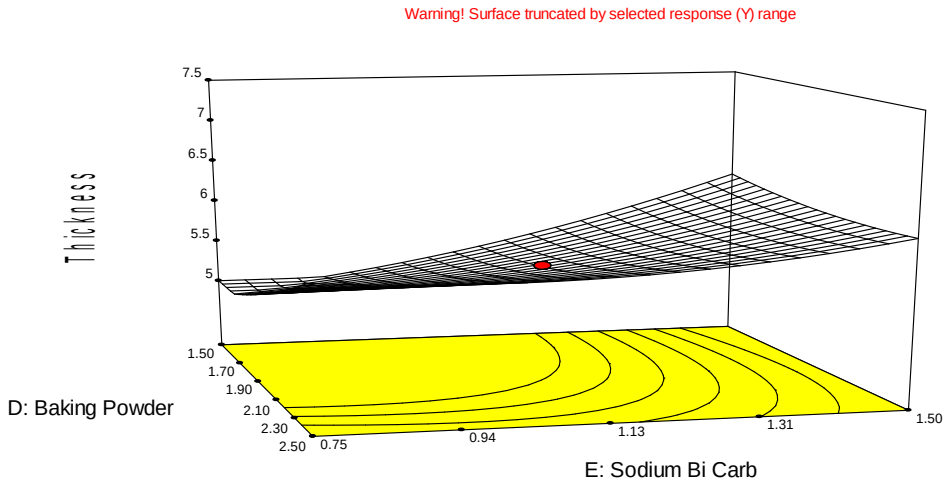

Fig 10 Effect of Baking powder and Sodium bicarbonate on thickness of cake

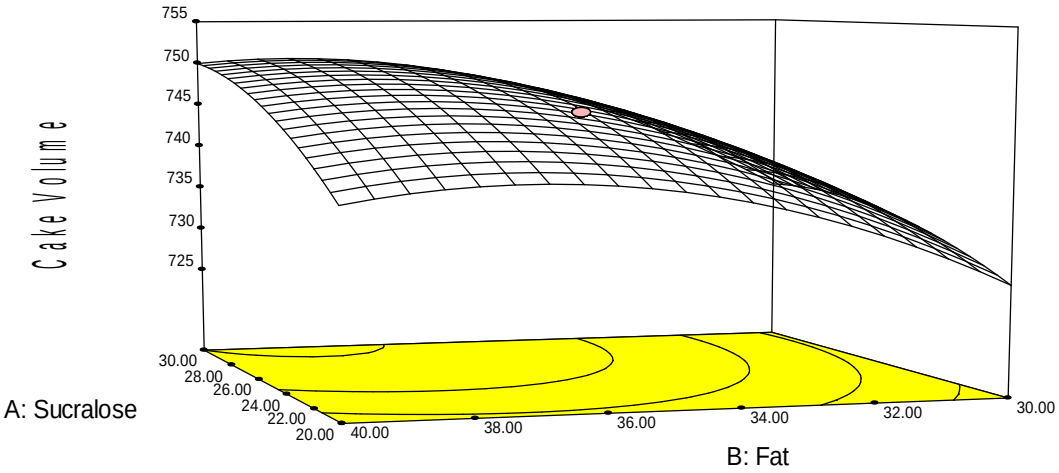

Fig 11 Effect of Sucralose and Fat on volume of cake

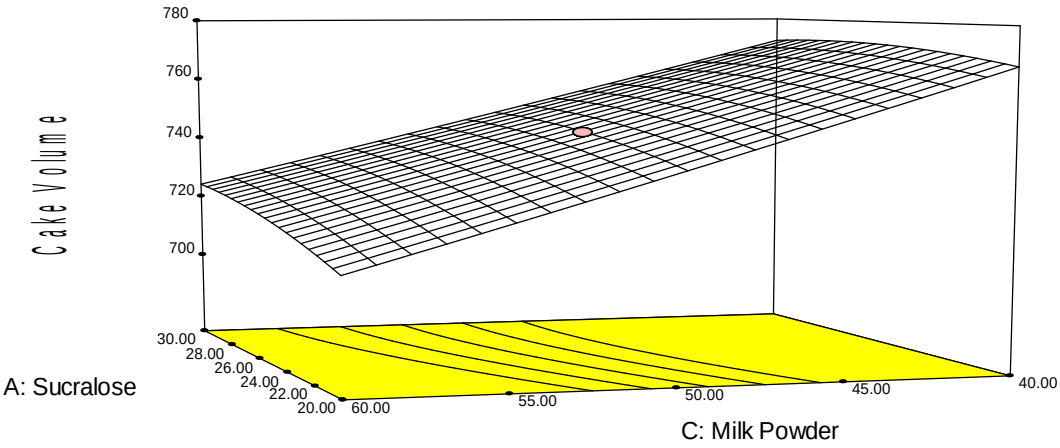

Fig 12 Effect of Sucralose and Milk powder on Volume of cake

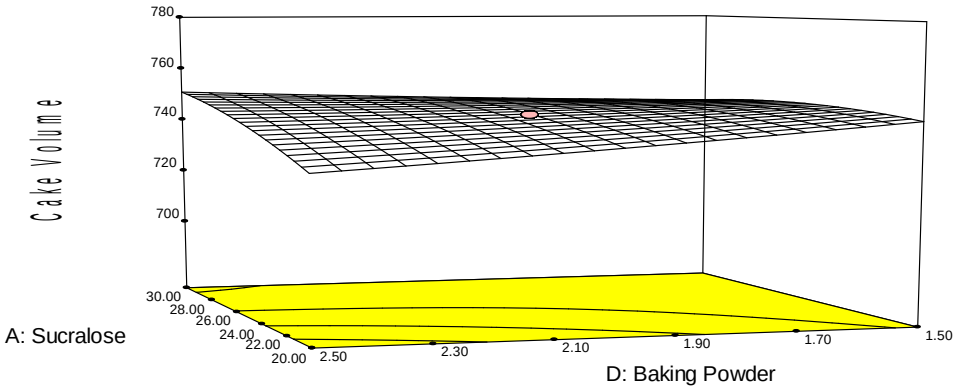

Fig 13 Effect of Sucralose and Baking powder on Volume of cake

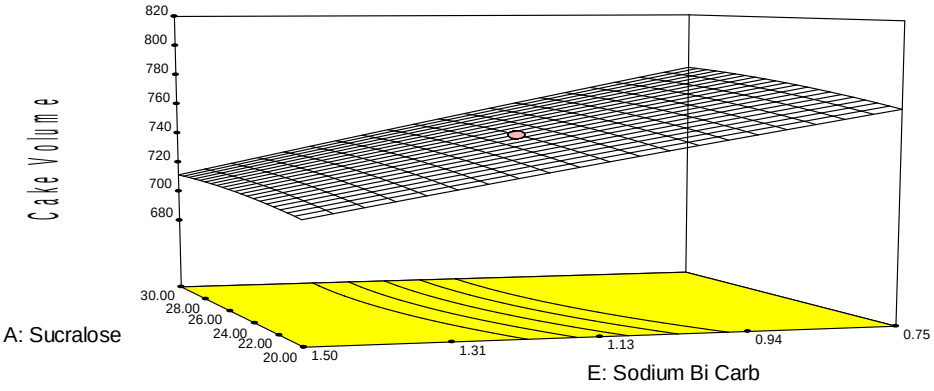

Fig 14 Effect of Sucralose and Sodium bicarbonate on Volume of cake

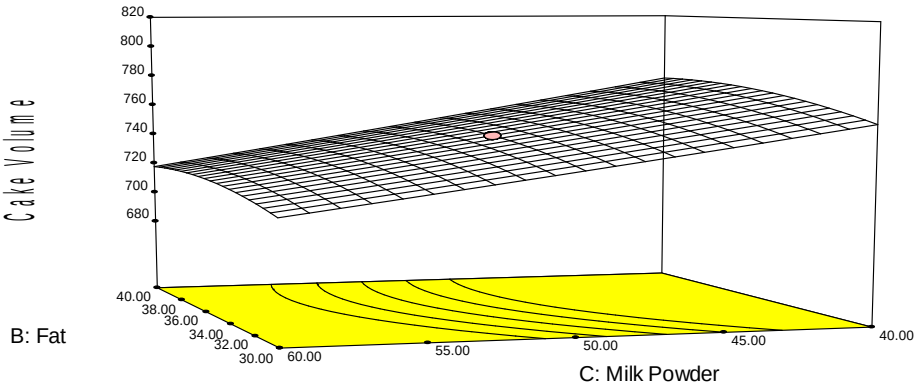

Fig 15 Effect of Fat and Milk powder Volume of cake

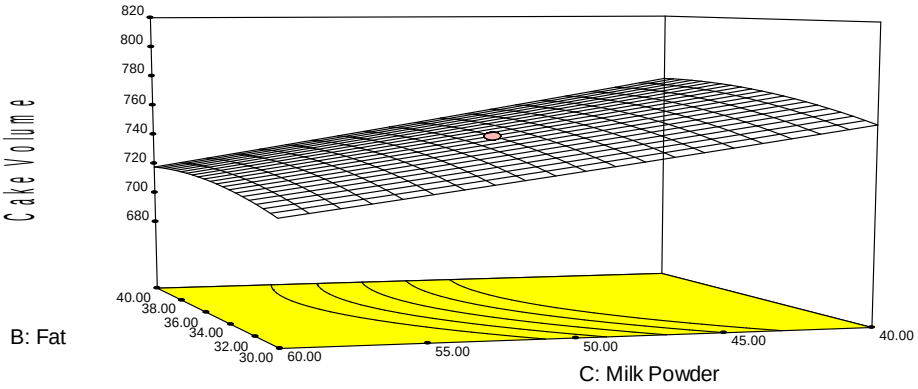

Fig 16 Effect of Fat and Baking powder on Volume of cake

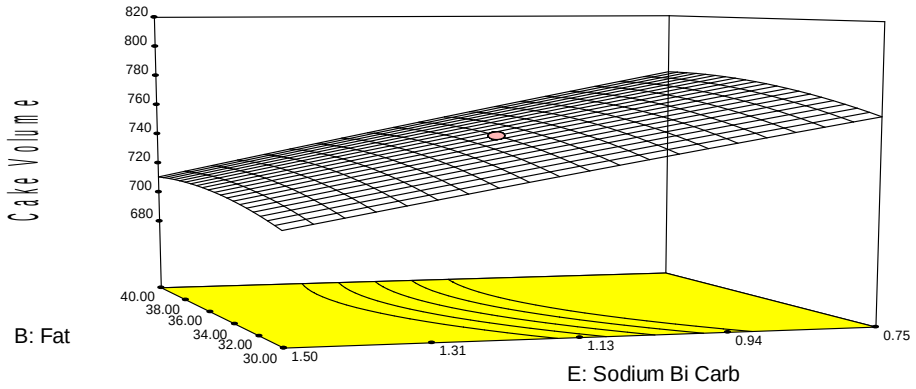

Fig 17 Effect of Fat and Sodium bicarbonate on Volume of cake

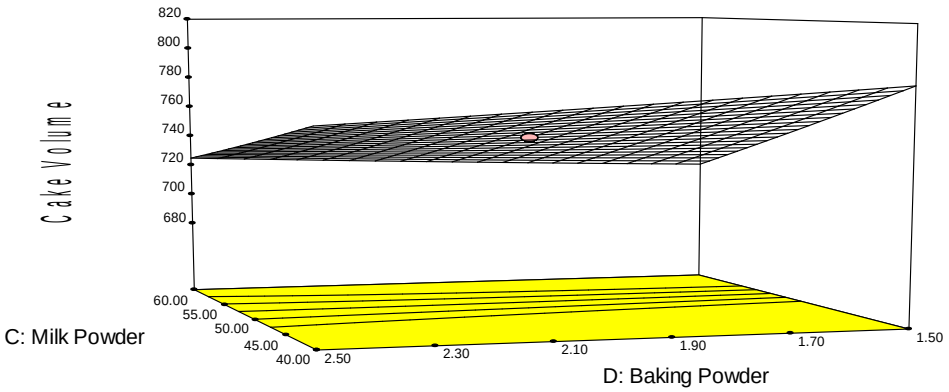

Fig 18 Effect of Milk powder and Baking powder on Volume of cake

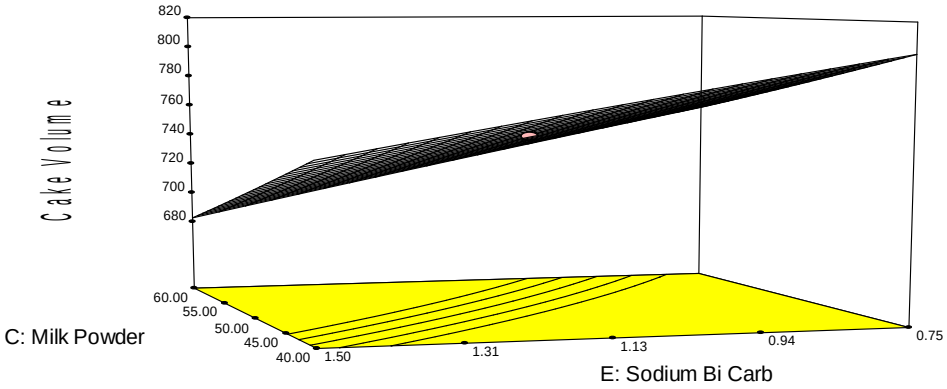

Fig 19 Effect of Milk powder and Sodium bicarbonate on Volume of cake

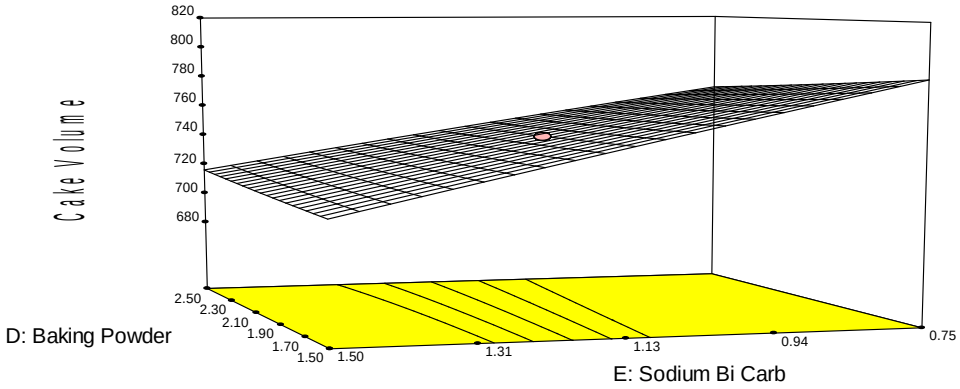

Fig 20 Effect of Baking powder and Sodium bicarbonate on Volume of cake

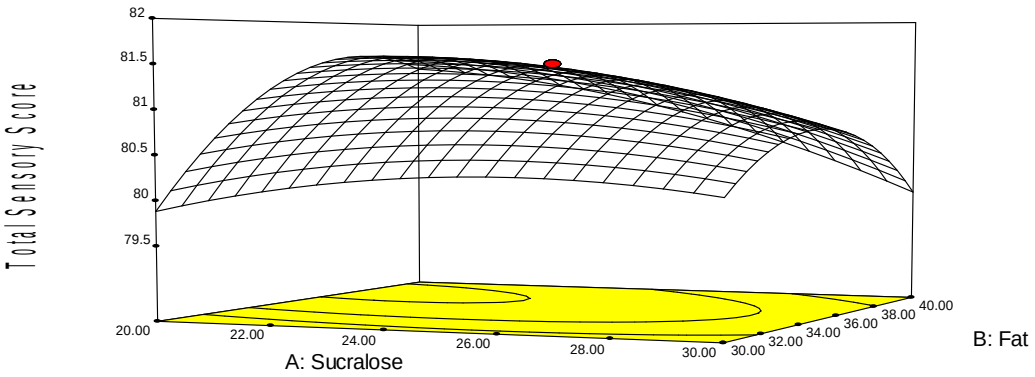

Fig 21 Effect of Sucralose and Fat on Total Sensory Score of cake

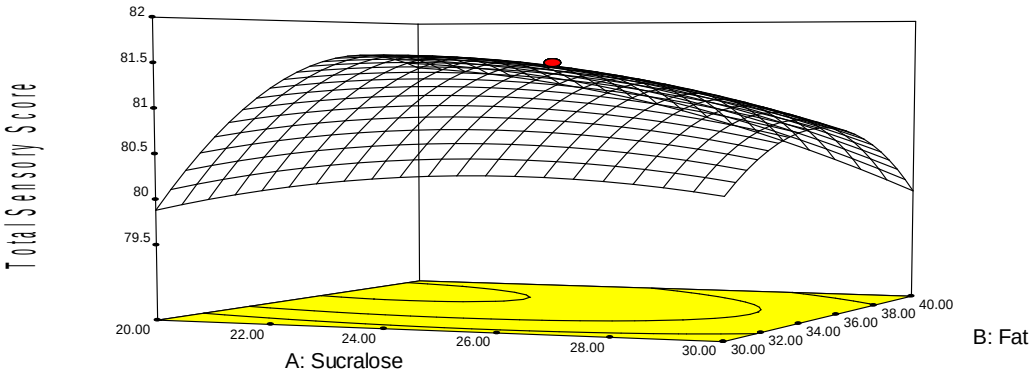

Fig 22 Effect of Sucralose and Milk powder on Total Sensory Score of cake

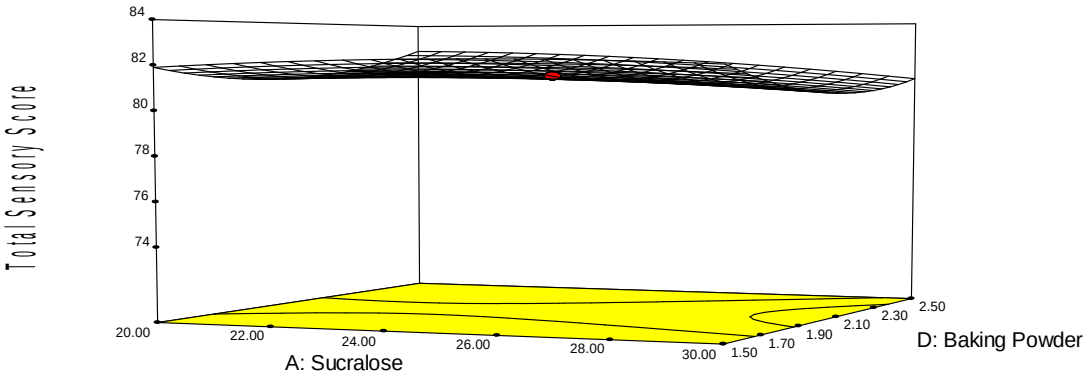

Fig 23 Effect of Sucralose and Baking powder on Total Sensory Score of cake

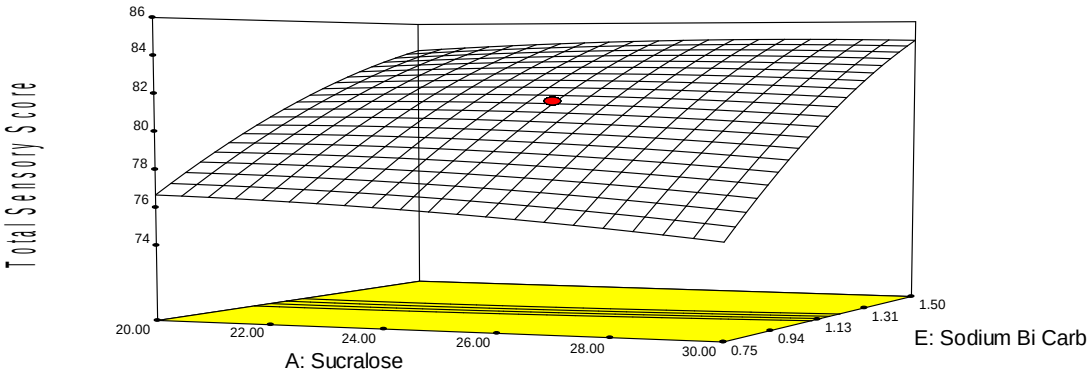

Fig 24 Effect of Sucralose and Sodium bicarbonate on Total Sensory Score of cake

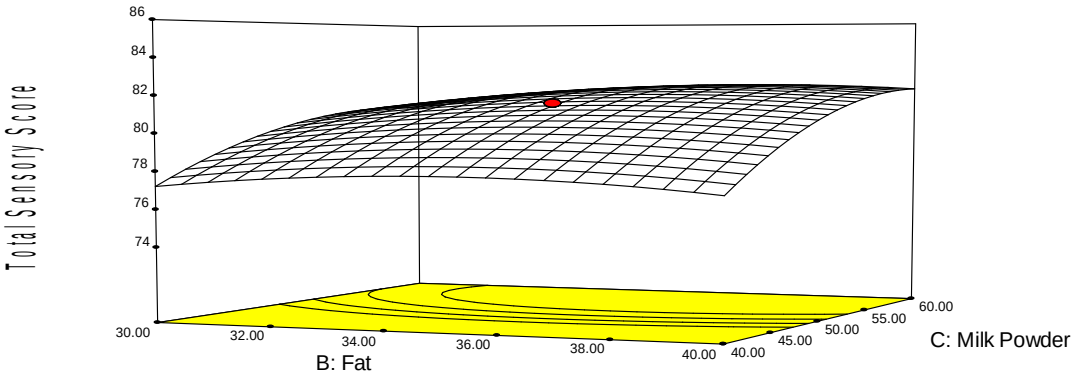

Fig 25 Effect of Fat and Milk powder on Total Sensory Score of cake

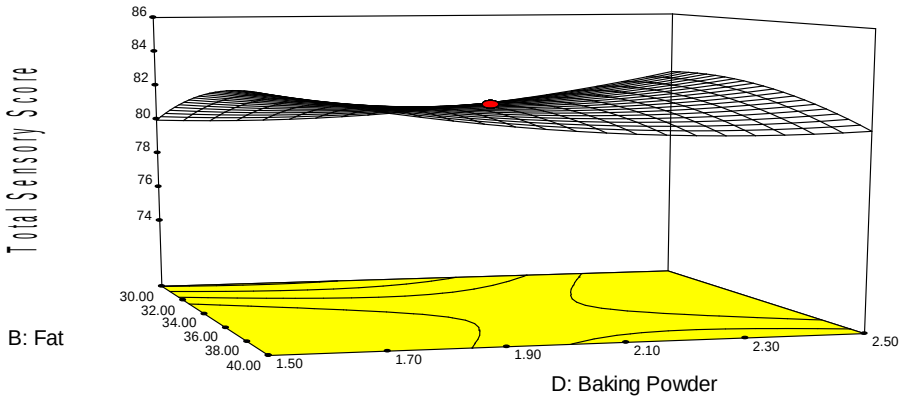

Fig 26 Effect of Fat and Baking powder on Total Sensory Score of cake

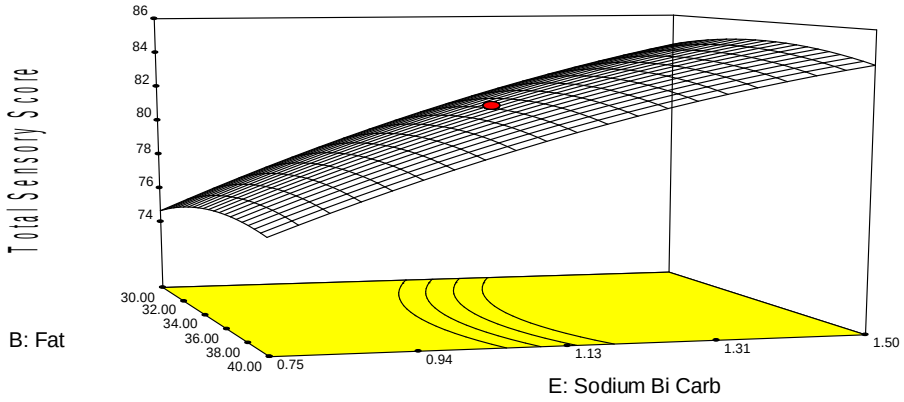

Fig 27 Effect of Fat and Sodium bicarbonate on Total Sensory Score of cake

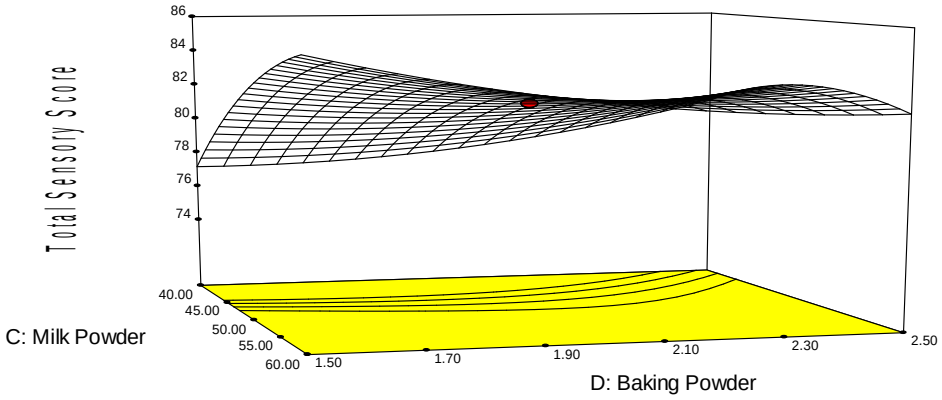

Fig 28 Effect of Milk powder and Baking powder on Total Sensory Score of cake

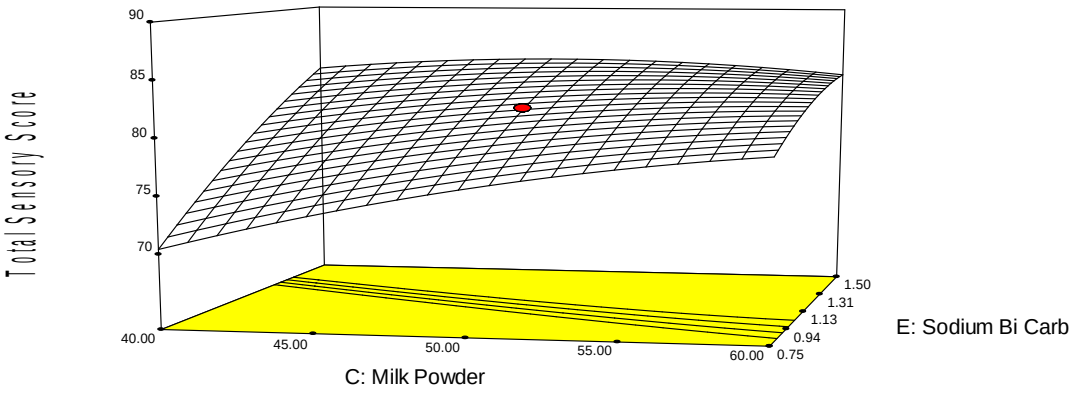

Fig 29 Effect of Milk powder and Sodium bicarbonate on Total Sensory Score of cake

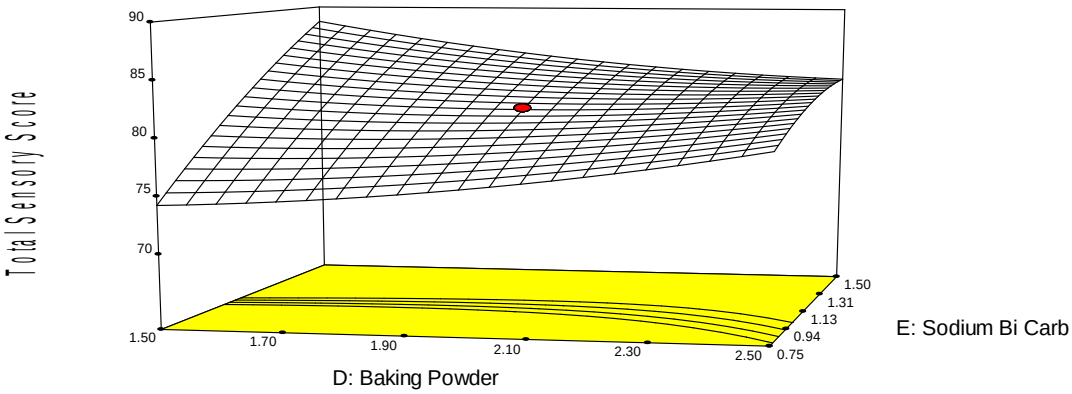

Fig 30 Effect of Baking powder and Sodium bicarbonate on Total Sensory Score of cake

Appendix I

Department of Food Science and Tech

JNKVV Jabalpur

Dear Panelist,

The sensory evaluation of products viz. Sugar free Cake is proposed to be conducted according to the method as described by AACC (1965) . You are requested to kindly conduct the test using attached score card.

Internal Factors (100 points)				**Score (Points)**
A.	**Cells (30 Points)**			
1.	Uniformity (10 points)	(a)	Even (normal)	10
		(b)	Slightly uneven	6
		(c)	Uneven	2
2.	Size (10 points)	(a)	Dense (normal)	10
		(b)	Close	8
		(c)	Slightly open	6
		(d)	Open	4
3.	Thickness of walls (10 points)	(a)	Thin (normal)	10
		(b)	Slightly thick	6
		(c)	Thick	2
B.	**Grain (16 points)**			
1.	Silky (normal)			16
	Harsh			10
	Coarse (corn bread)			8
C.	**Texture (34 points)**			
1.	Moistness (10 points)	(a)	Gummy	6
		(b)	Moist (normal)	10
		(c)	Slightly dry	8
		(d)	Dry	4
2.	Tenderness (14 points)	(a)	Very tender (normal)	14
		(b)	Tender	12
		(c)	Slightly tough	10
		(d)	Tough	4
3.	Softness (10 points)	(a)	Soft (normal)	10
		(b)	Slightly firm	8
		(c)	Firm	4
D.	**Crumb color (10 points)**			
1.	Bright white (normal)			10
2.	White			8
3.	Slightly dull			8
4.	Slightly creamy			8
5.	Creamy			6
6.	St. dull and sl creamy			4

E. **Flavor (10 points)**

1. Normal (no off flavor) 10
2. Foreign 0

Total 100

SNo	Product Exp NO	Cells	Grain	Texture	Crumb colour	Flavour

Remark

Signature

Name
Address

ABSTRACT

Title of the thesis	:	**"Optimization of levels of Baking ingredients for development of Sugar free Cake, using Sucrolase"**
Student's name	:	**KRISHN PAL BAGRI**
Permanent address		**Village & Post– Rajarwara, Tehsil - Nagod** **District - Satna** **Madhya Pradesh – 485 001**
Name and address of major adviser	:	**Dr. S.S. Shukla** **Professor** **Department of Food Science & Technology**
Degree to be awarded	:	**M.Sc. (Ag.)**
Year of award of degree	:	**2012**
Major subject	:	**Food Science**
Total no. of pages in the thesis	:	**65**
Number of words in the abstract	:	**263**

Signature of Advisor	Signature of Head of the Department	Signature of Student
(Dr. S.S. Shukla)	**(Dr. S. Kumar)**	**(Krishna Pal Bagri)**

ABSTRACT

Utilization of Sugar free ingredients in food products is an area of current interest because of nutritional awareness of consumer and changing demographics. Sucrolase a non sugar sweetener provides about 600 times of sucrose sweetness with no unpleasant residual flavour, non- caloric, non- cariogenic and proven as safe for human consumption. The replacement of sucrose with sucralose may cause deviation in physical and sensory quality attributes of cakes. The findings of present investigation envisaged that, diameter (13.8cm), thickness, volume, weight, density of sugar free cake varied from 4.7-7.5cm, 643- 840 cc/g, 307-250g, 0.31-0.43 g/cc. The moisture, protein, carbohydrate and fat content in cake sample varied from 18.66-28.88, 6.56-10.94, 32.-56.4, and 7.4-15.8 percent. The reducing sugar, non reducing sugar and total sugar content in cake were found to be 3.62-5.55, 3.91-11 and 9.05-15.62 percent. The results of sensory evaluation test of sugar free cake for various sensory attributes were found to be, cell (14.5 to 27.5), Grain (8.5 -14.5) Texture (20.25 - 32.25), Crumb (7.3 to 10), colour,(6.5 to 10), Total sensory score 61.0-91.5 respectively The effect of different levels of ingredients on various responses of sugar free cake, indicated that the ingredient level have linear and quadratic significant effect. The interactions were also significant for texture and overall acceptability response of the cake. It could be concluded that sucrolase along with other baking ingredients can be utilized for sugar free cake preparations. The best quality acceptable sugar free cake can be made by using the formulation of 20%, 40g, 60g, 1.5g, 1.5g, sucralose, fat, milk powder, baking powder and sodium bi carbonate respectively.