

**OPTIMIZATION OF JACKFRUIT SEED(*Artocarpus heterophyllus* LAM.)  
FLOUR AND POLYDEXTROSE CONTENT IN THE FORMULATION OF  
REDUCED CALORIE CHOCOLATE CAKE**

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REDUCED CALORIE CHOCOLATE CAKE**

**by**

**SITI FARIDAH BT MOHD. AMIN**

**Thesis submitted in fulfillment of the  
requirements for the degree  
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Sincerely,

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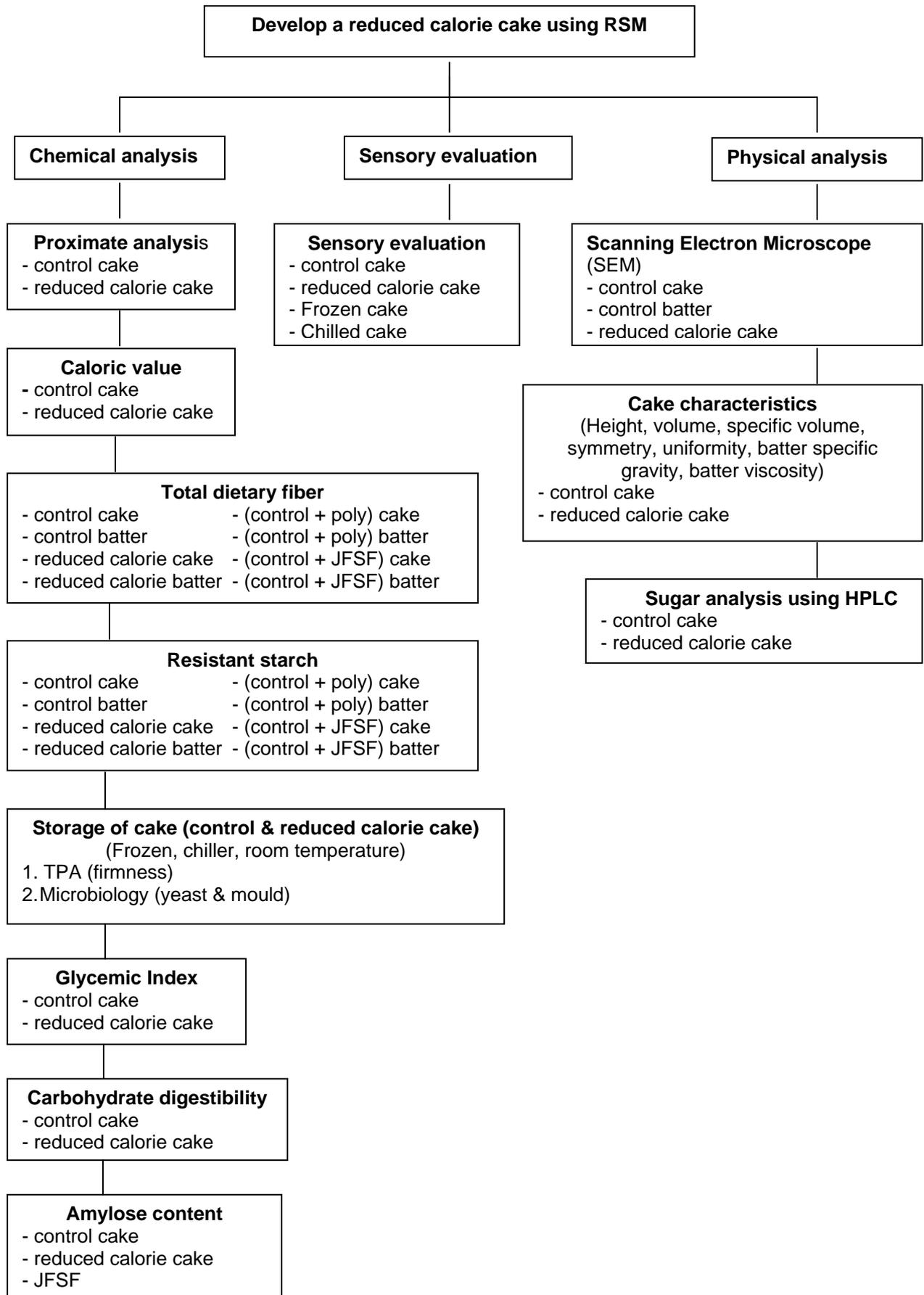
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## LIST OF ABBREVIATIONS

v/v	volume over volume
I.U	international unit
Kcal/g	kilo calorie over gram
Mg/l.g	milli gram over liter and gram
Dwb	dry weight basis
BU	brabender unit
P/F	pressure over fahrenheit
Pps	parts per second
Nm/sec	nano meter over second
mL	milli liter
CFU/g	colony forming unit over gram
Kg	kilo gram
Exp	Exponent
L	liter
µm	micro meter
mL/min	milli liter over minute
Ppm	parts per minutes
C/F	centipoises over fahrenheit
Rpm	rotation per minutes
Mg/g/h	milli gram over gram over hour
µg/mL	micro gram over milli liter
w/v	weight/ volume
IDF	Insoluble dietary fibre
SDF	Soluble dietary fibre
RSM	Response surface methodology
JFSF	Jackfruit seed flour

**PENGOPTIMUMAN KANDUNGAN TEPUNG BIJI NANGKA (*Artocarpus heterophyllus* LAM.) DAN POLIDEKSTROSA DALAM KEK COKLAT RENDAH KALORI**

**ABSTRAK**

Kek rendah kalori dihasilkan menggunakan program metodologi permukaan respon (RSM) dengan menggantikan sukrosa dengan 11% polidekstroza dan tepung gandum dengan 16% tepung biji nangka. Analisis proksimat menunjukkan kek rendah kalori adalah tinggi dengan kandungan lembapan (31.17%), gentian kasar (5.02%), dan protein (9.89%) tetapi rendah dalam kandungan lemak (3.53%). Dalam analisis fizikal, kek rendah kalori adalah tinggi dengan indeks simetri (2.20) berbanding kek kawalan (1.40) tetapi tidak menunjukkan perbezaan yang signifikan dalam isipadu spesifik dan uniformiti. Ia mempunyai nilai kalori (251 kcal/100g) yang rendah berbanding kek kawalan (379 kcal/100g). Kek rendah kalori adalah tinggi dalam kandungan jumlah dietari serat (13.13%), dietari serta tidak larut (13%) dan kanji rintang (4.5%). Keputusan analisis gula menunjukkan kek rendah kalori mempunyai kandungan yang rendah dalam jumlah gula (7.47%) tetapi tinggi dalam kandungan oligosakarida (5.49%) dengan tiada kesan flatulen kerana kandungan raffinosa oligosakarida (RFOs) tidak dapat dikesan. Ia rendah dalam kandungan sukrosa (6.23%), sodium (209.97 mg/100g) dan tinggi dalam kandungan kalsium (146.2 mg/100g) berbanding kek kawalan. Analisis SEM menunjukkan krum kek rendah kalori membentuk beberapa terowong dengan titisan lemak yang kecil dan bulat. Dalam penilaian sensori, penerimaan keseluruhan adalah tinggi dalam kek rendah kalori yang dibekukan pada suhu  $-20^{\circ}\text{C}$  berbanding kek rendah kalori yang disimpan pada suhu bilik ( $27^{\circ}\text{C}$ ) dan suhu dingin ( $4^{\circ}\text{C}$ ). Pengerasan krum kek rendah kalori yang disimpan pada suhu beku, dingin dan bilik meningkat dengan masa penyimpanan dan lebih keras berbanding dengan kek kawalan. Analisis yis dan kulat menunjukkan kek rendah kalori yang disimpan pada suhu dingin masih

diterima sehingga hari ke 21 ( $8.0 \times 10^3$  CFU/g) berbanding kek kawalan yang masih diterima sehingga hari ke 18 ( $8.0 \times 10^3$  CFU/g). Manakala kek rendah kalori yang dibekukan masih boleh diterima sehingga hari ke 40 ( $1.2 \times 10^4$  CFU/g). Jumlah produk karbohidrat terhadam (maltosa) (TCDP) yang dihasilkan ke dalam dialisat selepas 3 jam penghadaman adalah 276.56 mg/g/h dengan kandungan jumlah kanji terhidrosilis adalah 15.75% pada 280 minit dengan nilai glisemik indeks sebanyak 58.06.

**OPTIMIZATION OF JACKFRUIT SEED (*Artocarpus heterophyllus* LAM.)  
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**ABSTRACT**

Reduced calorie cake was developed from response surface methodology (RSM) programmed by replacing sucrose with 11% polydextrose and wheat flour with 16% jackfruit seed flour (JFSF). Proximate analyses indicated that reduced calorie cake was high in moisture (31.17%), crude fibre (5.02%) dan protein (9.89%) but low in fat (3.52%) content. In physical analyses, reduced calorie cake has higher symmetry index (2.20) as compared to the control cake (1.40) but showed no different in specific volume and uniformity. It has lower calorie value (251 kcal/100g) as compared to control cake (379 kcal/100g). Reduced calorie cake was high in total dietary fibre (13.13%), insoluble dietary fibre (13%) and resistant starch (4.5%) content. Sugar analysis result indicated that reduced calorie cake was low in total sugar (7.47%) but high in oligosaccharides (5.49%) content with no flatulence effect since raffinose oligosaccharides were not detected. It is low in sucrose (6.23%), sodium (209.97 mg/100g) and high in calcium (146.2 mg/100g) content as compared to the control cake. SEM analysis showed that crumb of reduced calorie cake developed a few tunnel with small and speherical lipid droplets. Sensory evaluation indicated that the overall acceptability was high in reduced calorie cake frozen at -20<sup>0</sup>C as compared to the reduced calorie cake which was stored at room (27<sup>0</sup>C) and chilled (4<sup>0</sup>C) temperatures. Firming of cake crumb in reduced calorie cake stored in frozen, chilled dan room temperature increased with storage time and was firmer than the control cake. In yeast and mould examination showed that rduced calorie cake stored at chilled temperature is still acceptable until day 21 (8.0 x 10<sup>3</sup> CFU/g) as acompared to the control cake which was acceptable only until day 18 (8.0 x 10<sup>3</sup> CFU/g). Frozen reduced calorie cake was

still acceptable until day 40 ( $1.2 \times 10^4$  CFU/g). The total carbohydrate digestibility product (maltose) (TCDP) released into dialysate over 3 hours in vitro digestion of reduced calorie cake was 276.56 mg/g/h. the total total hydrolysed content was 15.75% for 180 minutes and glysemic index value of 58.06.

## **CHAPTER 1 INTRODUCTION**

Cake is well liked by consumers all over the world. It is a very important product in the baking industry (USDC, 1979). The high caloric content over consumption of cake contributed to obesity among consumer. Awareness on nutritional and health among customer resulted in accelerated demand for reduced or low calorie and high fiber foods.

Altering level of ingredients and increased in fibre content for the purpose of calorie reduction affected the appearance, flavour and texture of the product. The changed will be noticeable by consumer and thus will influence their preferences (Nancy & Carole, 1986) on the products. The Response Surface Methodology (RSM) was used to optimize the cake formulation. RSM is a cost effective approach, time reduction and allows optimization of ingredient levels for specific desirable product characteristic (Johnson & Zabik, 1981). It is an attractive tool to formulate baked product because it is able to detect the optimal levels of several variables without the necessity testing to all possible combinations.

Response surface methodology (RSM) has been widely reported been used in development and optimization of cake formulation (Johnson & Zabik, 1981; Kissel, 1967; Lee & Hosney, 1982; Nancy & Carole, 1986; Vaisey-Genser *et al.*, 1987; Joglekar & May, 1987).

To increase the fibre content of the cake, jackfruit seed flour (JFSF) was substituted for wheat flour. Hasidah & Noor Aziah (2003) reported that JFSF was a

good source of fibre which contained high amount of 6.98% total dietary fiber (6.98%) and crude fiber (3.28%). JFSF has been successfully incorporated into bread at 25% level and was accepted by sensory panel (Hasidah & Noor Aziah, 2003). Thus, JFSF can be substituted at a certain level for wheat flour to satisfy consumer demands to increase fibre content in foods. The seed of jackfruit which is a waste from the fruit industry has commercial potential for application as a cheap source of fiber replacing wholemeal.

Polydextrose (Litesse<sup>®</sup>) was used to replace sugar to reduce the calorie content in the product. Polydextrose was chosen in this reasearchbecause it was low in calorie (1 kcal/g) compared to Simplese<sup>®</sup> (1-2 cal/g) and Maltodextrin<sup>®</sup> (4 cal/g) (Position of The American Dietetic Association, 1998) , poor in gastrointestinal absorption and high resistance to microbial degradation in the colon. Polydextrose (Litesse<sup>®</sup>) had similar technological properties to sugar and functions in food as humectants, bulking agent, stabilizer and texturiser (Figdor & Bianchine, 1981).

The lack of sweetness characteristic in polydextrose would be an advantage for its application in sucrose based food (Anibal & Raul, 1981). Combinations of polydextrose and sweetener allowed the sweetness level to be adjusted over a wide range (Anibal & Raul, 1981). Polydextrose (Litesse<sup>®</sup>) is non-glycemic; hence it does not create an insulin demand (Danisco, 2003).

The problem statement is in purpose to develop a reduced calorie chocolate cake substituted with jackfruit seed (*Artocarpus heterophyllus* lam.) flour (JFSF) and polydextrose by using response surface methodology (RSM) programmed. This

programmed was used to optimize the percentage of polydextrose and JFSF to be substituted in chocolate cake to produce a high acceptability and quality cake. Chocolate cake was chosen because it contains high fat and calorie and so decrease intake of it among customer who aware on nutritional and health lifestyle. Therefore this research is undertaken to develop a reduced calorie cake and high in fibre.

The main objectives of this study were:

1. To develop a low calorie and high fibre chocolate cake substituted with jackfruit seed flour (JFSF) for wheat flour and polydextrose for sugar by using central composite design in response surface methodology (RSM).
2. To study the effect of JFSF and polydextrose as sugar and fat replacer in chocolate cake in terms of the physical, chemical and sensory attributes.
3. To study the effect of sucrose ester as emulsifier in crumb development in chocolate cake.

## **CHAPTER 2 LITERATURE REVIEW**

### **2.1 Response Surface Methodology (RSM)**

#### **2.1.1 Introduction**

RSM was defined as a statistical method that used quantitative data from suitable experimental designs to determine and solve the multivariate equations (Cochran & Cox, 1975). These equations were graphically represented as response surfaces which are used to describe how the test variables affected the response, to determine the interrelationships among the test variables and to describe the combined effect of all test variables on the response (Giovanni, 1983). Application of RSM in any experiments or optimization process, will save time, cost, energy (Cochran & Cox, 1975), and helped in determining the caused of defects and also eliminated waste during production (Dziezak, 1990).

Response surface methodology (RSM) has been reported by many food researches and product developments such as in bread formulation design (Payton, *et al.*, 1988; Henselman *et al.*, 1974), cookies (Conner & Keagy, 1981) and also in development and optimization of baked goods formulation such as cake (Johnson & Zabik, 1981; Kissel, 1967; Lee & Hosenev, 1982; Neville & Setser, 1986; Vaisey-Genser *et al.*, 1987; Joglekar & May, 1987). It is a well-known statistical technique mostly suitable for product development (Ylimaki *et al.*, 1988) because it allowed optimization of ingredient levels for specific desirable product characteristics (Johnson & Zabik, 1981).

Experimental design was a general approach to be implemented in any experiments and RSM analysis. First, the experiment was design to determine the purpose of the study and identified the factors and responses. The factors were commonly known as independent variables included ingredients or processing conditions. Responses or dependent variables measured can be chemical constituents such as percent sodium, physical measurements such as viscosity, sensory scores, microbiological stability results, or shelf life of a product (Dziezak, 1990). Product development is generally done in two stages, namely screening and optimization (Dziezak, 1990).

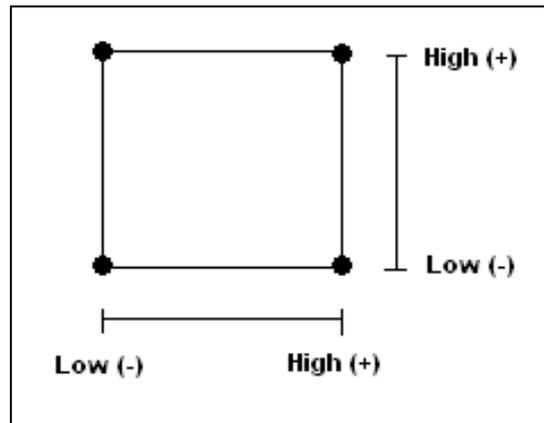
### **2.1.2 Screening**

The objective of screening is to determine the critical control variables from a collection of many potential variables (Joglekar & May, 1987) so that the experiments will be more efficient and required fewer runs or tests (Myers & Montgomery, 2002). It allows estimation of the effect of each factor and selects factors which produced a significant effect on the response for further experimentation (Dziezak, 1990). Two level factorial and fractional factorial designs are used for this purpose (Joglekar & May, 1987).

#### **2.1.2.1 Factorial design**

Factorial design is widely used in experiments involving several factors to investigate the interaction effects of the factors on a response variable (Myers & Montgomery, 2002) by conducting all possible combinations of variable and levels. In two level factorial designs, each variable is studied at only two levels, called the (-) and (+) levels which is known as  $2^k$  factorial design (Joglekar & May, 1987). In  $2^k$  design;

only two factors (A and B) are involved and each run at two levels. This design is called a  $2^2$  (4 factor combinations) factorial design (Myers & Montgomery, 2002). Figure 2.1 shows a plot of the experimental region tested in a  $2^2$  factorial.



**Figure 2.1: The  $2^2$  factorial design**  
(Source: Myers & Montgomery, 2002)

### 2.1.2.2 Fractional factorial design

Fractional factorial design is used to test only a fraction of the factor combinations in a full factorial design. It does not estimate the interaction effects between factors (Dziezak, 1990). An example of a one half fraction of a  $2^3$  design is designated as a  $\frac{1}{2} 2^3$  or  $2^{3-1}$  which have only four factor combinations compared to eight combinations in factorial design (Dziezak, 1990).

### 2.1.2.3 Addition of central point to factorial design

Addition of replicated centre points in a  $2^k$  factorial design is to provide a protection against curvature and to obtain an independent estimate of error (Myers & Montgomery, 2002).

#### 2.1.2.4 Blocking and randomization

Grouping together experiments is called blocking, which helped in removing experimental error, whereas randomization minimized the correlation with time (Dziezak, 1990). For an example, the  $2^k$  factorial design is replicated for  $n$  times. Each set of this design is considered as a block and each replicated of the design is run in a separated block. The runs in each block were made in random order (Myers & Montgomery, 2002).

#### 2.1.2.5 Analysis for screening experiment

In screening experiment, in the case of two independent variables or factors, the first order model is built after evaluating the effects and interactions as shown in Equation 2.1 (Myers & Montgomery, 2002).

First order model: 
$$y = \beta_0 + \beta_1\chi_1 + \beta_2\chi_2 + e \quad (2.1)$$

In the above,  $y$  represents the response,  $\chi$ 's represent factors,  $\beta_0$  represents the  $y$ -intercept,  $\beta$ 's are called parameters and  $e$  is the residuals. When a model is built, an analysis of residuals and analysis of variance (ANOVA) is calculated to evaluate how well the model represented the data which consisted of percent of confidence, percent of variation and coefficient of variation (CV) (Joglekar & May, 1987).

#### 2.1.3 Optimization

The objective of optimization is to identify the optimum levels of the factors investigated. It included both response surface methods and mixture experiments (Dziezak, 1990). In response surface method, quantitative data is used to build an

empirical model that described the relationship between each factor investigated and the response (Dziezak, 1990).

For product optimization experiments the model most often used was the full second order polynomial model which including the interaction effects between factors and curvature effects (Deming & Morgan, 1987) as shown in Equation (2.1) and (2.2) (Myers & Montgomery, 2002). The number of factors was usually limited to two or three (Dziezak, 1990) in response surface method. The model was used to evaluate the effects of each factor, interactions between and among factors and curvature (Myers & Montgomery, 2002).

Curvature effect represented by terms such as  $\beta_{11}\chi_1^2$  produced parabolic shapes when the model was graphed. These effects occurred when two different levels of the same factor produced similar values of response and higher or lower responses at intermediate factor levels (Dziezak, 1990).

Second order model:

$$y = \beta_0 + \beta_1\chi_1 + \beta_2\chi_2 + \beta_{11}\chi_1^2 + \beta_{22}\chi_2^2 + \beta_{12}\chi_1\chi_2 + e \quad (2.2)$$

Where  $y$  represents the response (e.g. volume),  $\chi_1$  represents the first factor (e.g. sugar),  $\chi_2$  represent the second factor (e.g. flour),  $e$  represents the usual random error component and  $\beta_0$  represents the y-intercept and  $\beta$ 's was the regression coefficient.

Central composite design (CCD) is widely used for fitting a second order method in response surface method which consisted of four runs at the corners of the square, four runs at the center of this square and four axial runs (Myers & Montgomery,

2002). It used to estimate parameters of a full second order polynomial model (Dziezak, 1990). CCD had been introduced by Box and William on 1957 which was divided into three point group of design; factorial, axial point and centre point (Deming & Morgan, 1987).

The empirical model was analyzed by generating the analysis of variance (ANOVA) to test the adequacy of the model. The tests included percent of confident, percent of variation, coefficient of variation (CV), 'Root MSE' value, press and  $R^2$  value (Dziezak, 1990). The empirical model was described in a three dimensional response surface plot. It represented a different response value and showed the factors levels responsible for that response which provided an understanding of how the experiment behaved when the factor levels were changed (Joglekar & May, 1987).

An appropriate model was choose when the 'press' and 'Root MSE' value was minimum and  $R^2$  value was maximum. According to Joglekar and May (1987), the maximum  $R^2$  value was not less than 80 % whereas coefficient of variation (CV) value of the model should not exceeded than 10 % which indicated that the model was significant and the confidence level of the chosen model was not due to the experimental error.

## **2.2 Prospects and Market of reduced / low calorie foods**

The increased demand for low fat and low or reduced calorie foods among consumers provided and opportunity for the food industry to develop healthy and reduced calorie food products which further increase the market size for these products. It was proven by the Calorie Control Council's (CCC) that 101 million Americans consumed low calorie foods and beverages in 1991, as compared to 93 million in 1989.

In 1978, the number of consumers using low calorie foods and beverages was only 42 million (Wilkes, 1992).

The food consumption trends in America showed that there is an increase conscious in calorie intake among customer. However there was low conscious of calorie intake pattern in Malaysia. According to FAO (1997), the intake pattern of calorie is increased from 2430 kcal person<sup>-1</sup> day<sup>-1</sup> in 1961 to 2990 kcal person<sup>-1</sup> day<sup>-1</sup>. The low awareness of calorie intake pattern in Malaysia is due to the growth in Malaysian population and economy, which resulted in rapid growth of fast food industry (EDGE, 2001) and 'westernization' of global eating habit among Malaysians which accelerated the intakes of food high in sugar, calories and fat (Noor, 2002).

Increased in obesity, cancer, coronary heart disease and stroke increased demands for low fat and low or reduced calorie foods in the market (Bogue & Delahunty, 1999). Most consumers selected calorie reduced foods to prevent obesity and maintain good health (IFIC, 2000).

The U. S department of health recommended reduction of sucrose intake in the diet to about 100ib/person/year (Bushkirk, 1974) so as to prevent dental caries, coronary heart disease, hyper tri-glyceridemia, diverticular disease, diabetes, dermatitis, detrimental change in vision and hypo-glycemia (Danowski, 1976). However, the reduced fat and calorie products are more expensive as compared to other common food products in the market (Holland, 1999).

The growing markets in low calorie and dietetic foods in United States approached to 3 billion dollars annually. This growing market included dairy products, soft drinks, confections, snacks, baked goods, canned goods, spreads and dressings (LaBell & O'Donell, 1997). The importance of reduced fat and reduced calorie products can be seen in 1996 sales where over 100 reduced fat or fat free products types amounted to \$16.7 billion or about 10% of the total consumer foods in the United States (LaBell & O'Donell, 1997).

CCC's survey found that the most popular low calorie foods and beverages were the diet soft drinks (consumed by 42% of adults), sugar free gum / candy (28%) and sugar free gelatins or pudding (18%) in U.S. (Wilkes, 1992).

## **2.3 Cake making process**

### **2.3.1 High quality cake**

Joseph & Donald (1974) defined cake as a baked product made with soft and low protein flour, water, sugar, eggs, some shortening, leavening agent, flavouring and milk powder. Cakes can be classified as:

1. Fat type cakes – pound, layer, cup and sheet cake.
2. Foam type cake – angel, chiffon, sponge and California cheese cake.

Good cakes possessed large volume, golden brown crust, smooth rounded top surface and bright texture crumb (Barrows, 1975). Good cakes had a multitude of evenly distributed minute cells without any large holes, moist, good flavour, low degree of shrinkage and with attractive general appearance (Bennion & Bamford, 1973). A high quality cakes had slightly rounded symmetrical tops, which was indicated by

negative, zero or positive value for sunken or rounded surface and had zero uniformity index which indicated an equal halved of cake (Stinson, 1986).

### **2.3.2 Methods of cake making**

#### **2.3.2.1 Sugar batter method**

The process started with formation of a light creamy mass of butters or margarines and sugars for 10 minutes. After each addition of eggs, the batter was beaten to prevent curdling at this stage. When all the eggs had been creamed in, the batter becomes lighter, creamier and more 'floppy'. At this stage flavouring agent was added. Finally, the sifted flour was gently mixed into the batter with addition of milk or water at the same time (Bennion & Bamford, 1973).

#### **2.3.2.2 Flour batter method**

Flour batter processed is a good way of making slab and pound cakes (Daniel, 1965). In this method, the fats were first creamed up with flour until a light creamy mass was obtained. Egg was then whisked separately for about 6 minutes before adding into the creamy mass (Bennion & Bamford, 1973). Flour batter method is useful in preventing full development of gluten and losing aeration through curdling of batter (Daniel, 1965).

#### **2.3.2.3 Sugar / flour batter method**

The sugar / flour method was similar to the flour batter method with exception that the fats and sugars were creamed lightly together in the bowl, before flour was creamed in. When the mixture was light, egg and flavours were creamed in to produce a light velvety batter. The remainder of the flour was then mixed in (Bennion & Bamford, 1973).

#### **2.3.2.4 Continuous method**

The continuous method was applied mostly in large cake production. In this method the slurry of liquid sugar, eggs, milk and flour was mixed and emulsified it with shortenings and then the mixture was mixed continuously in a cake mixer (Bennion & Bamford, 1973).

#### **2.3.2.5 All in method**

All in method was used in many types of cake processing. In this process, all the ingredients were weighed, placed in the mixing machine and beaten together. The advantaged of using this method is summarized as below (Bennion & Bamford, 1973):

1. Eliminate the human element
2. Save time
3. Ease of cooperation
4. Improved batter stabilization
5. Greater machine utilization
6. Complete one stage mixing

#### **2.3.3 Mistakes and faults in cake making**

Two major faults in cake making which affected the quality of cake known as 'M' and 'X' faults. The 'M' fault is caused by excess baking powder, sugar or fat and incorrect baking temperature. The 'M' faults is shown when the cake collapsed in the centre after being withdrawn from the oven and caramelization throughout the whole crumb occurred due to slow baking (Barrows, 1975). Oven temperature is maintained by placing tins of water in the oven or having the oven filled up with cakes as possible.

A humid atmosphere in the oven helped in forming slower top crust which, thus allow the batter to expand to it fullest volume (Daniel, 1965).

The 'X' fault was due to excess liquid during the mixing process. It was named as 'X' fault because when the cake was cut the outline had the shape of the letter (Barrows, 1975). One of the faults in cake was due to unsuitable raw materials such as 'rotteness' in margarine or butter which prevented easy creaming and excess fat resulted in a wet crumb and a greasy to the cake (Daniel, 1965). Common faults and their causes in cake making process are summarized in Table 2.1.

## **2.4 Function of cake ingredients**

### **2.4.1 Wheat flour**

Flour was a final product from milling of wheat and contained a mixture of proteins, starches, sugars, fats and mineral salts. There were 4 grades of flour used in confectioneries products. The strong flour is employed in bread and buns making. The medium flour is used in making brioche, all kinds of scones, aerated buns, aerated cakes such as lurch, Madeira and queen cakes so as to obtain a better texture and appearance. It is also used in making cherry and heavy fruit slab cakes in order to prevent crumbliness and sinking of fruit to the bottom of the cake. Another type of medium flour is the self raising flour which has been blended with a proportion of baking powder at approximately 2% of the flour (Hanneman, 1980), calcium acid phosphate, baking soda, and salt (Joseph & Donald, 1974).

**Table 2.1: Common faults and causes in cake making process.**

Fault	Cause
Weak streak under top of cake	1. Under baking 2. Cake being knocked or moved during baking 3. Too hot oven
Weak streak at bottom of cake	1. Too much liquid 2. Insufficient baking powder 3. Insufficient sugar 4. Using soft type flour 5. Weak or insufficient egg
Collapse in centre of cake with white spots on the crust	1. Excess of sugar
Collapse in the centre of cake with dark crust	1. Excess of baking powder
Small volume and collapse at the sides and shrinking from the sides	1. Excess of liquid 2. Insufficient of egg 3. Using soft type flour
Small volume with 'cauliflower' at the top	1. Too hot oven 2. Insufficient steam in oven 3. Using a strong type flour 4. Too much egg 5. Insufficient sugar
Too tender crumb	1. Too much fat than egg
Crumbly crumb with coarse open texture	1. Weak flour 2. Too much fat than egg 3. Too much sugar 4. Slow baking

(Source: Bennion & Bamford, 1973).

The soft flour is suitable for making puff pastry, pound and slab cake. The chlorinated flour is suitable for high ratio cakes (Bennion & Bamford, 1973). The composition of wheat flours are shown in Table 2.2. Protein, the main component in flour helped in baking quality. The protein components formed elastic dough when mixed with the right amount of water. The formed dough holds the gas which developed into a spongy structured during baking (Frank, 1983). Starch is one of the carbohydrate components in flour which has 19% to 26% of amylose. Starch is one of the major

factors which influence the flour baking quality. The ash and lipids of wheat flour had a minor effect on the baking properties (Samuela, 1989b).

**Table 2.1: The composition of wheat flours**

Components	Minimum (%)	Maximum (%)
Protein	7.50	16.0
Carbohydrate as starch	6.80	76.0
Fat	1.00	1.5
Fiber	0.40	0.5
Ash	0.32	1.0

(Source: Schopmeyer, 1960)

#### **2.4.2 Egg**

Eggs affected flavor, color and texture of bakery products. The two main components of egg are the yolk and egg white. An egg yolk contained lipid and protein as the main constituent with various inorganic elements such as phosphorous, calcium and potassium. Eggs are widely used as an emulsifier in mayonnaise, cream puff and cheese soufflé. It is also used as a gelling agent in custards, as a coating material for croquettes, as a thickening agent in soft pie fillings and as a structural material to give rigidity to the crumb in quick breads, cakes, soufflés and shortened cakes (Samuela, 1989a).

The physical properties of eggs are important in baking cake include (Pylar, 1989a):

1. Whipping ability - is a foaming power of the ingredient to incorporate air as small bubbles and to maintain the bubbles or foam structure. When the egg foam is heated, the air trapped within the bubbles will expand; thereby increasing the volume of the foam. The foam then become rigid and thus increased the crumb volume. Protein components of egg white are ovalbumin, conalbumin, ovomucoid, lysozyme, globulin and ovomucin

have the ability to form very stable foam. When egg whites are whipped by mechanical means, it will form a large surface area of new surface, unfold and spread the proteins as a monomolecular layer over the new surfaces.

2. Coagulation - eggs have good binding and thickening properties in batters and dough because the proteins bond the water and established interlacing network of hydrogen bonded molecules. When the cake is baked, some of the proteins begin to coagulate at the lower end of the range and set up the foam batter structure. The structure is elastic because the proteins do not coagulate until the cake structure is expanded and set in its final form at the upper end of the critical temperature range was approached.

3. Emulsification – Egg yolk is a very efficient emulsifier due to the presence of lecithin in the yolk.

4. Food value - high content of proteins, fats, minerals and vitamin in eggs increased the food value and imparted a better colour and appearance to the finished products.

### **2.4.3 Margarine**

Margarine is an emulsion of edible oils and fats with milk. The composition is similar to butter (Bennion & Bamford, 1973). It contained fats (82–84%), moisture (13.5–12.0%), curd (1.5-1.7%) and salt (1.5-2.5%). Margarine is lacking in flavour characteristic of butter but it tasted like butter. Cake margarines have good creaming and shortening properties whereas pastry margarines were specially designed for use in pastry (Bennion & Bamford, 1973).

#### 2.4.4 Milk

Milk is the most important moistening agent used in every bakery products, both in bread and confectionary. As shown in Table 2.3, milk consists of proteins, sugars, fats, and minerals salts. The protein in milk has some effect on keeping the baked goods moist and mellow. The mineral salts are also an important asset which gives added value in food. Milk has a high percentage of water which is used as a source of water in foods such as cakes, breads and cream soups. The fat of milk confers richness and bloom. Milk is not nearly as sweet as cane sugar but it imparted a certain amount of sweetness and bloom to confectionary (Bennion & Bamford, 1973).

Milk is also rich in vitamins A and vitamin B and some thiamine is essentials in every food. Thiamine is a good source of niacin and an excellent source of riboflavin. Milk is used in many batter mixings in the placed of eggs. It is also employed in egg and corn flour custards and in the preparation of much food stuff (Bennion & Bamford, 1973).

**Table 2.3: The composition of milk**

Components	Content (%)
Water	87.4
Protein	3.5
Carbohydrate	4.9
Fat	3.5
Ash	0.7
Calcium	110 mg/100 ml
Magnesium	15 mg/100 ml
Zinc	0.4 mg/100 ml

(Source: Samuela, 1989c)

#### 2.4.5 Sugar

Sugars belong to a class of compounds known as carbohydrate. Sucrose is a disaccharide formed by the combination of one molecule of monosaccharide glucose

(dextrose) with one molecule of monosaccharide fructose (laevulose) through carbon 1 and 2 and with loss of one molecule of water (Helen, 1982).

Nesetril (1967) reported that formation of crust color is due to caramelization and Mailard reaction which occurred between reducing sugars and proteins found in the flour. The caramelization and Mailard reaction will lower the temperature and shorten the baking time with more moisture remaining in the loaf. The hygroscopic nature of sugars retained the moisture content in the loaf which helps in extending the shelf life of cake. Flavour and aroma developed in cake is due to the volatile acids and aldehydes found in sugar.

Sugar imparted a smoother, softer and whiter crumb in cake. Sugars also delayed the starch gelatinization, protein denaturation and tenderizing action during cake baking. The functions of sugar and other cake ingredients in baking process are summarized in Table 2.4.

#### **2.4.6 Cocoa powder**

Cocoa powder imparted flavour, color and food value to various types of confectionaries (Pylar, 1989b). Chocolate and cocoa contain a high level of flavonoids, specifically epicatechin, which may have beneficial cardiovascular effects on health. Cocoa powder is neutral and does not react with baking soda. It has a reddish-brown color, mild flavor, and is easy to dissolve in liquids.

**Table 2.4: Cake ingredients and their functions.**

Main functions	Ingredients								
	Flour	Sugar	Shortening & Batter	Salt	Egg yolk	Egg white	Flavor	Leavening agent	Milk
Binding action	X								
Absorbing agent	X								
Aids keeping qualities	X	X	X						
Affected eating qualities	X								X
Nutritional value	X	X	X		X				
Affected flavor	X		X		X				X
Added sweetness		X							
Produced tenderness		X							
Affected symmetry		X						X	
Imparted crust colour		X							
Shortness or tenderness			X						
Eating qualities			X						
Color		X							
Volume						X		X	
Structure						X			
Grain and texture						X		X	X
Added quality to product			X	X					X
Brings out flavor							X		X

(Source: Joseph & Donald, 1974)

Its delicate flavor makes it ideal in baked goods like cakes and pastries where its subtle flavor complements other ingredients. When used alone in cakes, cocoa powder imparts a full rich chocolate flavor and dark color. Cocoa powder can also be used in recipes with other chocolates and this combination produces a cake with a more intense chocolate flavor than if the cocoa was not present (Rose, 1997).

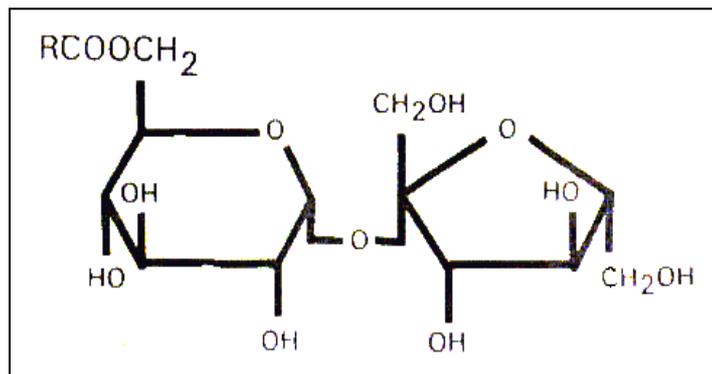
#### **2.4.7 Emulsifier (Sucrose Ester F-160)**

Emulsifiers are interfacial components that are used to improve the stability of the emulsion. It is also known as the surface-active agents or surfactants which aid in stabilizing the emulsion by lowering the interfacial tensions between water and other liquids (Allen, 1989). According to Krog and Lauridsen (1976), emulsifiers are divided into three main groups:

1. Those that reduced surface tension at oil / water interfaces and promoted emulsification and formation of phase equilibrium between oil / water emulsifier at the interface which stabilized the emulsion.
2. Those that interacted with starch and protein components in foods that modified texture and rheological properties.
3. Those that modified the crystallization of fats and oils.

##### **2.4.7.1 Chemical structure of sugar ester**

Sucrose fatty acid esters are nonionic surfactants consisting of sucrose as hydrophilic group and fatty acid as the lipophilic group is generally known as sugar ester (Figure 2.2) (Ebeler & Walker, 1984). It is manufactured by the Dai-Ichi Kogyo Seiyaku Company Limited, Kyoto, Japan.



**Figure 2.2: Chemical structure of sucrose ester**  
(Source: Ebeler & Walker, 1984)

Sucrose ester is synthesized from the transesterification reaction between sucrose and methyl esters of fatty acids in the presence of a catalyst and dimethylformamide (DMF) (Osipow *et al.*, 1956).

The properties of sugar ester are:

1. Tasteless
2. Odorless
3. Nontoxic
4. Non-irritant to the eyes and skin
5. Suitable not only to food but also for pharmaceuticals and cosmetics
6. Excellent biodegradability, did not cause environmental pollution
7. Good surfactant functionality
8. Easy to prepare
9. Good batter stability – aerated batter stays stable for as long as two or three hours
10. Longer shelf life – anti staling keeps cake crumbs soft and tasty

(Mitsubishi-Kagaku Foods Corporation, 2002).

#### **2.4.7.2 Application of sucrose ester in foods**

Baked goods without emulsifiers are reported to be tough, dry, stale, leathery or tasteless (Frank, 1983). Sugar ester is used in various food products such as in wheat products, confectioneries and dairy products as shown in Table 2.5. The functions of emulsifiers in cakes are as follows:

1. To promote the emulsion aeration and control the agglomeration of fat globules and stabilized the aerated system.
2. To improve the shelf life of cakes through the interaction with starch polymers.
3. To increase the cake volume by 10% to 20% and resulted in finer crumbs and more uniform texture.
4. To reduce the usage of egg and shortening.
5. To improve machinability.
6. To improve flavour released.
7. To improve hydration rate of flour and other components.

**Table 2.5: Various applications of sugar esters to foods.**

<b>Applications</b>	<b>Effects</b>
<b>Wheat products</b> 1. Bread 2. Noodle	<ul style="list-style-type: none"> <li>• Strengthen the dough and increased mechanical resistance during kneading.</li> <li>• Increased volume after baking and softens crumb will resulted in uniform cavities and saved shortening oil.</li> <li>• Maintained softness of crumb after baking and lengthen the shelf life.</li> <li>• Maintained the volume after baking and improved the quality even if the flour is mixed with sorghum or corn flour.</li> <li>• Prevent mixed dough from sticking to the machine and to each other.</li> <li>• Increased the water content and yield by decreasing the elution of starch into boiling water.</li> </ul>
<b>Confectioneries</b> 1. Biscuits, cracker and cookie 2. Chocolate	<ul style="list-style-type: none"> <li>• Emulsion of fatty materials is stable and prevent from sticky to the machine.</li> <li>• Prevent bloom in high fat biscuits products.</li> <li>• Increased volume after baking and improved the grain and shortness.</li> <li>• Lower the viscosity and promote coating and tempering.</li> <li>• Improved heat deformation of chocolate and reduced oil separation.</li> <li>• Increased water resistance and prevent sugar blooming.</li> </ul>
<b>Dairy products</b> 1. Ice cream 2. Whipping cream	<ul style="list-style-type: none"> <li>• Improved overrun by preventing excessive cohesion of fat during freezing due to stable emulsification and provided smooth and melty taste.</li> <li>• Provided stable emulsification during distribution. Enhanced stand up quality and provided adequate overrun.</li> <li>• Prevented water separation.</li> </ul>

(Source: Mitsubishi-Kagaku Foods Corporation, 2002)