

THE EFFECT OF STORAGE AND DIFFERENT  
COOKING METHODS ON THE NUTRITIONAL  
QUALITY OF CHICKEN BREAST

by

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## ABSTRAK.

Daging ayam merupakan makanan lauk yang paling popular digunakan berbanding dengan jenis lauk yang lain dan kualiti pemakanan (nutrisi) bahagian dada ayam dipengaruhi oleh penyimpanan dan kaedah memasak yang berbeza seperti mendidih, menggril menggoreng dan memanggang. Satu kajian telah dijalankan untuk menentukan nilai-nilai pemakanan (nutrisi) untuk isi dada ayam yang segar dan isi dada ayam yang telah disejukbekukan selama 7 hari dipengaruhi oleh jenis memasak yang berbeza. Analisis proksimat telah dijalankan mengikut prosedur AOAC (1996). Keputusan menunjukkan bahawa isi dada ayam sejuk beku disediakan dengan kaedah menggoreng mempunyai signifikan ( $P < 0.05$ ) yang paling rendah kandungan lembapan/air (58.46%) berbanding dengan jenis masakan lain. Kandungan lemak (12.73%) dalam isi dada ayam segar dengan kaedah menggoreng tertinggi ( $P < 0.05$ ) manakala kandungan protein tertinggi ditemui dalam isi dada ayam dengan kaedah mendidih (14.26%). Isi dada ayam segar yang disediakan oleh kaedah menggoreng mempunyai signifikan ( $P < 0.05$ ) tertinggi kandungan kalori (5.68 kcal / g) berbanding dengan mendidih (5.46 kcal / g), panggang (5.39 kcal / g) dan gril (5.41 kcal / g). Kesimpulannya, proksimat dan kandungan kalori dalam isi dada ayam berbeza, kesan daripada perbezaan kaedah memasak dan penyimpanan.

## ABSTRACT

Chickens are the most popular poultry consumed than others and its nutritional quality of chicken breast is affected by frozen storage and different cooking methods such as boiling, grilling, deep-frying and roasting. A study was conducted to determine the nutritional values in fresh and 7 days of storage of chicken breast meat as affected by different type of cooking. Proximate analysis was carried out following the procedures of AOAC (1996). The results show that storage chicken meat prepared by deep-frying methods had significantly ( $P < 0.05$ ) lowest moisture content (58.46%) compared to other type of cooking. The fat content (12.73%) in fresh chicken meat by deep-frying method was significantly highest ( $P < 0.05$ ) while the highest protein content was found in chicken meat by boiling method (14.26%). Fresh chicken breast meat prepared by deep-frying method had significantly ( $P < 0.05$ ) highest calorie content (5.68kcal/g) compared with boiling (5.46 kcal/g), roasting (5.39 kcal/g) and grilling (5.41 kcal/g). In conclusion, chicken breast varied in proximate and calorie content, which in turn is affected to varying degrees by cooking methods and frozen storage.

## DECLARATION

I hereby declare that the thesis is my original work except for the quotations and citations which have been duly acknowledged. I also declare that it has not been previously, and is not concurrently submitted for any other degree or purposes in Universiti Sains Malaysia or at any other institutions.

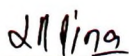


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I certify that Ms Suzyelawati Binti Mohd Shukri has carried out her study entitled **“The effect of storage and different cooking methods on the nutritional quality of chicken breast meat”** as a final year research project in nutrition under my supervision. She has complied with the ethical standard and regulations in conducting her study and has completed writing her thesis. I am satisfied with her work and have no objection for the thesis to be examined by the appointed examiners by the School of Health Sciences, Universiti Sains Malaysia.

Thank you.



Name of Supervisor: Dr Marina Abdul Manaf

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## LIST OF ABBREVIATIONS

<b>Symbol</b>	<b>Abbreviations</b>
<b>AOAC</b>	Association of Analytical Communities
<b>kcal</b>	Kilocalorie(s)
<b>g</b>	Gram(s)
<b>Kcal/g</b>	kilocalorie per gram
<b>/</b>	Per
<b>WHC</b>	Water-holding capacity
<b>%</b>	Percent (parts per hundred); percent age
<b>°C</b>	Celcius
<b>°F</b>	Fahrenheit
<b>USDA</b>	United State Department of Agriculture Food Safety and Inspection
<b>SFA</b>	Saturated fatty acids
<b>PUFA</b>	Polyunsaturated fatty acid
<b>HAAs</b>	Heterocyclic aromatic amines
<b>C</b>	Carbon
<b>H</b>	Hydrogen
<b>O</b>	Oxygen
<b>ω/n</b>	Omega
<b>TBA</b>	Thiobarbituric acid
<b>MDA</b>	Malondialdehyde
<b>mg</b>	Milligram(s)
<b>ml</b>	Milliliter(s)
<b>HCl</b>	Hydrochloric acid
<b>cm</b>	Centimeter(s)

<b>min</b>	Minute(s)
<b>BTU</b>	British thermal unit
<b>PSI</b>	Per square inches
<b>ANOVA</b>	Analysis of variance
<b>MDC</b>	Mechanically deboned chicken
<b>pH</b>	Measures the hydrogen ion concentration
<b>ATP</b>	Adenosine triphosphate

# CHAPTER I

## INTRODUCTION

### 1.1 Introduction

The word poultry refer to all domesticated birds raised for their meat. Although chicken are the most popular poultry consumed, other species include turkeys, ducks, geese and guinea fowls. Younger poultry (15-week-old / Four-month-old) (Vieira et al., 2009) are usually preferred because they are more tender and have less fat than older bird. Usually the weights of the chicken ranged from 800 to 1100 g (Hoffman et al., 2012). There are many types and style (processed) of poultry available in the market. Type of poultry refers to fresh, frozen, cooked, sliced, canned and dehydrated whereas style refers to the degree to which it has been cleaned or processed, that is live, dressed, ready-to-cooked or convenience categories (Brown, 2008).

Presently, freezing poultry becomes a common practice even in market and household for raw poultry. Freezing and storage the poultry has been widely used as the safest and most economical preservation method (Yoon, 2002). Nutritional quality of chicken breast was affected by storage and different cooking method. Different cooking method influences on cooking loss especially on quality characteristic of chicken breast meat (Barbanti et al., 2005). Chilling process is aim to reduce the growth of both pathogenic and food spoilage microorganisms. After slaughter, to maintain high quality

and safe product, the poultry carcass has to be chilled to reduce and then maintain the target temperature of the meat (James et al., 2006).

There are some advantages of frozen storage such as insignificant alterations in product dimensions, and minimum deteriorations in product colour, flavour, and texture but it also has some disadvantages such as freezer burn, product dehydration, rancidity, drip loss and product bleaching. Furthermore, this problem can be minimizing by thawing process. The poultry storage temperature must be passed through rapidly the critical temperature zone which is between 10<sup>0</sup>C and 2<sup>0</sup>C (Obuza et al., 2003).

The quality of poultry meat which was influenced by a series of factors ranging from the physical and chemical to the histological properties and processing procedure of poultry meat were affecting the consumer acceptance (Alvarado et al., 2004). During cooking process meat will change of both physical and chemical, including weight loss, modifications of water-holding capacity, muscle fibre shrinkage, colour and aroma development which was powerful dependent on protein denaturation and water loss (Walsh et al., 2010).

Moisture content and water-holding capacity (WHC) are common parameters to describe water status in meat. Water was important property in defining of fresh and cooked meat as well as in the development of the cooking process and also important to characterize the status of water in meat and its dependence on the cooking process (Hullberg et al., 2005).

Besides that, freezing and thawing affect the content and the distribution of moisture in meat tissue as a quality characteristic parameter in meat (Leygonie et al., 2012). Bacterial growth has been stop while the poultry was frozen, but precaution should be taken during and after thawing because any bacteria that were present may be begin to grow.

Proximate, fatty acid composition and cholesterol content of poultry were affected by varying degrees of cooking methods (Hoffman et al., 2012). Deep-fat (or immersion) frying was the process by which food was cooked in an oil medium (Ngadi et al., 1997) and cooking of food in enough hot fat or oil for the food to float on it (Bognár, 1998). Deep fat fried products were very popular items around the world. Skinless chicken breast fillets were deep fat fried ( $190^{\circ}\text{C} \pm 10^{\circ}\text{C}$ ) up to 6 min and with internal temperature reaches around  $70^{\circ}\text{C}$ . After processing done, the products increase in weight which results of absorption of a small amount of oil (Barbut, 2012). Protein, carbohydrate and mineral(ash) of poultry by frying method had been maintain compared to boiling and steaming method which the content of mineral(ash) had been decrease about 25-50% (Bognár, 1998).

Another type of cooking method was grilling. Grilling is a form of cooking that involves dry heat applied to the surface of food, commonly from above or below. Grilling usually involves a significant amount of direct, radiant heat, and tends to be used for cooking meat quickly and meat that has already been sliced (or other pieces).

Food to be grilled has cooked on a grill (open wire grid). The cooking time varies according to thickness, usually chicken take around 20 minutes per side.

Roasting is the process of frying of mostly protein containing food with or without fat in an oven (Bognár, 1998). Roasting or baking is another method of cooking method that can retain the juicy of breast meat. Roasting is similar like baking but the term usually applied to meat and poultry (Brown, 2008). Roasting used more indirect, diffused heat (as in oven) and has suitable for slower cooking of meat in a large, whole piece. A heavy-duty roasting pan must be used for the best result, if not it promote the loss of tasty juices to be collect later.

Boiling which is the process of whole or cut-up fresh poultry can be covered in water that must reach boiling point 212<sup>0</sup>F (100<sup>0</sup>C), at sea level. The temperature at boiling point which water bubble rapidly (Brown, 2008). Poultry must be heated until well done to improve flavour. Most research has focused on temperature history. (Chang et al., 1998) reported temperature histories at various locations in a whole poultry during roasting and found that the slowest heating point located at the middle of the breast. The thickest breast and thigh zones were thought to be the parts having the slowest heating point. Following the United State Department of Agriculture (USDA) Food Safety and Inspection recommendation, the final temperature at the slowest heating point of poultry is 163<sup>0</sup>F (72.8<sup>0</sup>C)

Doneness can be detected by many indicators like internal temperature, colour change, touch and time. For internal temperature it must reach a minimum of 74<sup>0</sup>C. For colouring, the skin of chicken reaches a golden brown colour (Brown, 2008). The purpose for carrying out this research project was to determine the nutritional quality of chicken breast meat by different type of cooking methods before and after storage.

## **1.2 Research Problem Statement**

Nowadays, most of the people around the world are likely to consume domestic animals especially chicken meat than other animal foods like beef and pork. Poultry such as chicken meat is an important food commodity in China, and the production and consumption of poultry have increased steadily in recent years. The major processed poultry products in China include deep-frying chicken and roasted chicken (Liao et al., 2010). Besides that, most of them get the frozen chicken compared to fresh one. Consumption and consumer acceptance of frozen chickens have been on the improvement because of three main factors which are improved methods of packaging, improved methods of freezing and lastly improved methods of marketing (Demby et al., 1980).

This study has been undertaken to make certain that fresh chicken is the best way to get all nutritional value compared to frozen storage meat. Longer storage of the meat may cause the microbiological activity which may associated with the health issues. In recent years, storing meat under freezing conditions increase in order to address market

problems, and significant beef stocks has been generated. These stocks are often stored frozen for various times before being thawed to be consumed (Liu et al., 2003).

Furthermore, chicken meat can be cook in various types of cooking methods like roasting, deep-frying, pan-frying, stir-frying, boiling, microwave, grilling, steaming, oven, braising, sautéing and poaching. Deep fat fried products are very popular items around the world. Deep-frying automatically make the consumer taking more fat in meal especially. This would increase the number of people suffering with obesity and it is associated with chronic disease like heart disease, high blood pressure and diabetes. Types of cooking methods are very important in order to maintain healthy. Apart from that, this study has been undertaken to recommend to all population the best cooking method that is more practical in their life. Experimental design has been implied to determine the best cooking methods. The nutritional values of every cooking method has been calculated.

Today, a significant amount of chicken is marketed in the precooked frozen form. Processors use a variety of methods in precooking, ranging from open kettle to pressurize steam or pressurized deep fat frying. After precooking, the product is frozen and may remain in frozen storage for several months before it is reheated and consumed. During storage, precooked chickens first lost its “freshly cooked” flavour, then developed a “warmed over” flavour, and eventually developed rancidity. Precooked chicken stored at  $-17.8^{\circ}\text{C}$  did not develop detectable off flavours until 2 months, lack of freshness until 4 months, and rancidity until the eighth month. Warmer storage

temperatures drastically reduced those storage times. All indications are that precooking and freezing affects shelf life and nutritional value when compared to raw freezing (Liao et al., 2010).

Definitely, this study can bring the greatest benefits in promoting population's health and indirectly assist in the prevention of several chronic diseases such as obesity, diabetes, stroke, heart disease and cancers. It is because the incidences of preventable chronic diseases are increasing and becoming a major problem currently.

### **1.3 Research Objective**

#### 1.3.1 General objective:

To investigate the changes of nutritional (proximate) value including moisture, protein, fat, calories and carbohydrate of chicken breast meat before and after 7 days of refrigerated storage (-18°C) as influenced by different type of cooking methods (boiling, grilling, deep frying and roasting).

#### 1.3.2 Specific objective:

1. To determine the effect of different cooking methods on the nutritional quality of chicken breast.
2. To determine the effect of storage on the nutritional quality of chicken breast

#### **1.4 Research Question**

1. Are there any proximate compositions differences between fresh and 1 week storage of chicken breast?
2. Is the nutritional quality different by various type of cooking methods?
3. What is the best type of cooking methods that can retain the highest percentage of nutritional quality?

#### **1.5 Hypothesis**

##### **1.5.1 Null Hypothesis ( $H_0$ ):**

There is no significant difference in the nutritional quality of fresh and stored chicken breast prepared by different cooking methods.

##### **1.5.2 Alternative Hypothesis ( $H_A$ ):**

There is significant difference in the nutritional quality of fresh and stored chicken breast prepared by different cooking methods.

## CHAPTER II

### LITERATURE REVIEW

#### 2.1 Health relation:

Lipids were the importance content in meat in human diet and consumers have increased interest in the fat composition of food (De Marchi et al., 2012). Nutritional guidelines recommends to reduce the total fat intake, accompanied by decrease of saturated fatty acids (SFA) and increase of polyunsaturated fatty acid (PUFA) to avoid health disorders in order to avoid cardiovascular-type diseases (Sierra et al., 2008).

Unhygienic practise in handling meat may introduce harmful pathogen and in fact may cause some infection after eating. Safety requirement are needed more critical, particularly respect to food pathogens. Besides that, thermal processing can decrease the number of pathogens such as *Salmonella spp.*, *Escherichia coli* and *Staphylococcus aureus* (Siripon et al., 2007). Microbial inactivation can be calculated at the slowest heating point of the temperature of the food sample. This temperature and heating time are importance indicators to make sure the food are safety (Siripon et al., 2007). According to Chang et al., (1998), the slowest heating point located at the middle of the breast by roasting methods.

Cancers are strongly associated with our diet. Several epidemiological studies, development of cancer are more associated from consumption of fried and roasting meat (Knize et al., July 1994). Heterocyclic aromatic amines (HAAs), potent mutagens present at ng/kg levels in cooked foods which play an important role in the aetiology of human cancer (Sugimura et al., 2004).

Mostly, cooked foods that presence of HAAs has been become more interest for consumers. Poultry can be prepared in various type of cooking methods, so the level of HAAs will present in many level (Oz et al., 2010). According to Oz et al., (2010) the HAAs level are highest in the deep-fried chicken breast and not in the roasting methods.

## **2.2 Factors of Temperature and time on quality of chicken breast:**

Optimum cooking times certainly at the slowest heating point of temperature (Siripon et al., 2007). Temperature different is the result from the energy that transfer which define as heat. Temperature difference is the driving force of heat flow. Temperature is parallel to heat flow (Hanson, 1990). The best predictions can be obtained at the lower frying oil temperatures and shorter frying times apparently due to the influence of the interaction between liquid and vapour moisture diffusivities (Ngadi et al., 1997).

Alvarado et al., (2004) reported that early post-mortem (PM) muscle stimulation may cause tougher of the meat. Then, deboning the meat before the completion of rigor mortis (4 to 6 h pm) may decrease the tenderness. Vieira et al., (2009) reported that water holding capacity of meat decrease during frozen storage. Meat that kept frozen at -20°C for two months report the higher water loss compared to chilled meat. These differences in water loss between chilled and thawed meats decreased explain as previous ageing period increased. Frozen meat aged for 2 days were 25% higher than those for 14 days chilled meat (Vieira et al., 2009). Some study reported that, frozen storage could affect microbiological quality and physicochemical characteristics such as oxidative stability and sensory properties (Damen & Steenbekkers, 2007; Farouk & Weliczko, 2003; Hinton et al., 1998).

Fresh and ready-to-cooked poultry can be kept in the refrigerator at 4°C or below only up to 3 days because iron in myoglobin of poultry meat act as metal catalyst to speed up the reaction of the polyunsaturated fatty acid. This will results in unpleasant odour. Dark meat has higher myoglobin content compared to white meat. Chicken leg with their dark meat cannot be store as long as chicken breast. Besides that, it should be stored in vapour-proof wrapping to prevent from bacterial contamination and kept at the bottom part of the refrigerator to avoid sopping from contaminating other foods (Brown, 2008).

### **2.3 Nutritional aspect:**

Meat contains lipids which is useful as energy for the human body (Hoffman et al., 2012). Fatty acid and cholesterol content of the total fat in the diet have risk factors that associated with coronary heart disease and cancer, therefore have become more important to the consumer (Sales et al., 1996). Glucose contain carbon (C), hydrogen (H), and oxygen(O) sources that help the body in the synthesis of most fatty acids it needs, but it is unable to synthesis double bonds in the  $\omega$ -3 and  $\omega$ -6 positions. Usually these fatty acids are not found in beef and other animal products due to high saturated fatty acid and monounsaturated fatty acid levels. They are more abundant in fish and some poultry (McWilliams, 2001; Whitney, 2005). Poultry meat is referred as white meat compare to red meat. They have different in the fat content, which is the white meat containing low fat content compared to the red meat. Besides that, protein, glucose and creatine also differed (Borgen et al., 2001).

There are no significantly different of moisture loss due to cooking between fresh and frozen meat samples. That is because due to the region in the muscle tissue from which cooking-loss water originates. During cooking, the melting of the fat and the denaturation of the proteins reportedly cause the release of chemically bound water (Vieira, 2009).

## **2.4 Nutritional quality affected by different cooking methods:**

Latif (2010) reported that cooking losses from frying method is higher than boiling and grilling methods. Besides that, the chemical composition of chicken breast meat will significantly change through the cooking methods. When the absences of crust on the sample's surface, that will allowed the evaporation of water and melted fats to leak out from the sample. That is the explanations of cooking loss result (Murphy et al., 2000). Water holding capacity (WHC) is report higher in boiling and roasting cooking methods compared with others. Frying sample reported have lowest moisture content than other methods and roasting sample reported that, they have lowest lipid content (Latif, 2010).

Frying of breaded meat, poultry and fish whether in a pan or by deep - frying, it is associated with fat uptake around 2 - 14 g per 100 g of raw food while non - breaded high fat contained food of animal origin loses fat during frying in range 2 - 30%. Besides that, the fat quantity absorbed during frying is increases up to a saturation limit which is depending on the kind of food and on the amount of panade. Deep - fried meat, poultry and fish usually absorb less fat than meat, poultry and fish fried in a pan. The types of fat use for cooking had no essential influence on fat uptake. After frying of breaded meat, poultry and fish, the content of protein, carbohydrates and minerals was nearly fully retained while boiling reduced the mineral content around 25-50% (Bognár, 1998).

According to Zheng et al., (1998), when samples are heated above 60°C, the moisture content will be decreased. Meat tended to be more light and turned to brown – grey colour when introduced to heating temperature. The lightening is explained by the denaturation of protein (Young et al., 2001). One of the more heat-stable of the sarcoplasmic proteins which is almost completely denatured between 80 and 85°C is myoglobin (Spanier, 1994). Cooking of chicken breast will change dramatically its microstructure (Latif, 2010). Cooking process will make raw meat edible and acceptable and some chemical changes will occur but depending on the muscle, cooking time and temperature. Fat content is not affected by cooking methods, although breast has the lowest fat content but cooking method will affect the cholesterol content (Joseph et al., 1996).

According to Hoffman et al., (2012) the moisture content of the open-roasting methods is not surprising due to air is a poor heat conductor. It is suggested that, the internal temperature of open-roasting cuts are not the same as the baking bag and foil wrap methods, which by their wrapping trap the steam and at last will result in higher internal temperature. The end-point (internal) temperature of open roasting is not controlled because of rapidness of the external layer of meat to dry and will result in less water leaving in the inner meat. Only the cooking time and oven temperature will be controlled.

Breast cut has higher protein content in the open-roasting method compared with the other cooking methods (Hoffman et al., 2012). Meat processing methods such as storage and cooking cause an increasing oxidative rancidity in meat which measured by thiobarbituric acid (TBA) test for malondialdehyde (MDA). Chicken meat has high tendency to oxidative rancidity because of the highly polyunsaturated nature of chicken fat (Marion, 2006). The concentrations of MDA and TBA numbers increased after cooking and storage (Pikul et al., 1984).

Despite the popularity of deep-fat fried foods, little has been done to understand the dynamics of the process. According to Blumenthal (1991) deep-frying is still considered by many as an art rather than a science or technology. During the process, moisture is transferred from the food material into the frying oil medium. It is automatically desirable to minimize moisture loss from the food. Knowledge of moisture transfer during deep-fat is important in determining and maintaining quality of fried food. Very limited studies have been reported on moisture transfer in meat samples during deep-fat frying. Morgan et al., (1991) proposed a macro-empirical approach to modelling moisture loss during deep-fat frying of chicken-on-the-bone due to the difficulty of estimating moisture diffusivity during deep-fat frying process. Besides that, moisture loss for a given size of chicken piece at a specific oil temperature could be modelled as an exponential function of time. According to Ngadi et al., (1995), moisture diffusivity of chicken muscle during deep-fat frying using the regular regime theory. The term of effective moisture diffusivity was used as explanation of liquid and vapour moisture diffusivities in chicken muscle.

## **2.5 Moisture content in the chicken breast after storage and cook:**

The lowest protein content in cuts may be as a result of high moisture content (Hoffman et al., 2012). Hamm (1981) reported that muscles with high protein content is due to more connective tissues concentrated. High protein content will cause high moisture loss. Moisture loss are dependent on protein content that will denature at varying temperatures, which cause structural changes such as the destruction of cell membranes, transverse and longitudinal shrinkage of muscle fibres, the aggregation of sarcoplasmic proteins and shrinkage of the connective tissue (Honikel, 1998). According to Heerden et al., (2002), breast cuts that cooking by open-roasting methods have highest value of protein content and the finternal temperature of 85<sup>0</sup>C was controlled.

During the process deep-frying method, moisture is transferred from the meat into frying oil medium. It will reduce the percentage of moisture from food. That percentage is important to ensure the quality of fried food (Ngadi et al., 1997).

Diffusion activity of the moisture of chicken muscle during deep-frying is explain by the regular regime theory (Schoeber, 1976). Moisture transferred from chicken meat in the form of liquid and vapour during deep-frying methods. Higher temperature of frying oil can cause the high rate of moisture vaporisation and lower values of surface moisture as a result. Low surface moisture content would normally result in dryness of the chicken meat (Li, 2005).

Besides that, gentle boil is used to avoid the spillovers, burns and loss of cooking liquid through evaporation. A lid on the pot will bring liquid to boil by raising pressure. Then, when the boil temperature reached, the lid must be removed to reduce the heat setting. That is because, food are not cooked any faster at higher setting than gentle boil (Brown, 2008).

## **2.6 Effect of storage on nutritional quality of chicken breast:**

Storage of the meat will affect the protein content of the meat. According to Kozová et al., (2009), the protein content decrease continuously as long as the meat in storage. Besides that, dry matter content decreased during the storage period. Effect of frozen storage length and post-mortem ageing on microbial count are explain that frozen storage until 90 days may result of microbiological quality after thawing or 10 days did not cause spoilage of meat (Vieira et al., 2009).

## **CHAPTER III**

### **METHODOLOGY**

#### **3.1 Study Design**

An experimental method of research was performed to assess the nutritional quality of chicken breast meat by different type of cooking methods before and after storage. Uncooked fresh chicken breast serves as a control in the experiment.

#### **3.2 Collection of Sample**

Eight fresh skinless chicken breast fillets were obtained locally from slaughterhouse around Kubang Kerian. Meanwhile, fat/oil and other ingredients were purchased from local supplier. Fillets received were made certain freed from visible blood splash or bruising and weight was  $180\text{g} \pm 0.5\text{g}$ . Any remaining surface fat were removed physically after visual inspection. Meat samples were divided into two group which were four fresh skinless chicken breast fillets used immediately or shortly after purchase and the other four fresh skinless chicken breast fillets were freezed ( $- 18^{\circ}\text{C}$ ) for 1 week (7days). Then the skinless chicken breast fillets were cooked with different type of cooking methods (grill, boiling, roasting and deep frying). One uncooked and fresh skinless chicken breast fillet was used as a control. Cooking losses were measured for both cooking methods (dry and moist) as part of the standard procedure. Seven days later the procedure was repeated for the frozen samples.

### **3.3 Inclusion and Exclusion Criteria**

#### 3.3.1 Inclusion criteria :

- ✓ Breast part of chicken
- ✓ Fresh skinless chicken breast fillets
- ✓ Chicken breast fresh from slaughterhouse

#### 3.3.2 Exclusion criteria

- ✓ Other part of chicken meat
- ✓ Long storage of chicken breast
- ✓ Chicken breast meat from supermarket
- ✓ Breast fillet from other domestic animal

### **3.4 Chemicals and Reagents**

Petroleum ether (b.pt. 30 – 80<sup>0</sup>C), sulphuric acid (98%), catalysts tablet (high selenium), sodium hydroxide solution (40%), boric acid solution (4%), indicator (dissolve 80mg methyl red and 20mg methyl blue in 95% ethanol and make up to 100ml with 95% ethanol), hydrochloric acid (hcl) (0.1n), concentrated hydrochloric acid, water bath, distilled water.

### **3.5 Glassware**

Aluminium dish with lid, dessicator jar, crucible, 100ml flask, filter paper (whatman no.41 paper), dry trimble, receiving flask, burette, kjeldahl digestion flask, c4 combustion crucible.

### **3.6 Instruments**

Hot air-oven sterilizer (105 – 110<sup>0</sup>c), blender, electric coil heating rack, cold muffle furnace, soxhlet (extraction equipment), distillation unit, calorimeter, ika calorimeter system c2000 basic, pelleting press, decomposition vessel c5010, cotton thread, handle, venting button, crucible holder, analytical balance, kjeldhal, kjeldatherm.

### **3.7 Sample preparation**

Four pieces of fresh chicken breast were washed using tap water and all the fat around the meat was physically removed. Then, the chicken breast meats were weighed for  $180\text{g} \pm 0.5\text{g}$ . Before weighing, samples were blotted with a paper towel to remove excess surface moisture. Every pieces of unflavoured chicken breast were then cooked with different type of cooking methods such as roasting, grilling, deep-frying and boiling.

For frozen (-18<sup>0</sup>C) chicken breast meat, the meat were thawed at room temperature (22<sup>0</sup>C) for 1 hour in storage plastic bags before cooking.

### **3.8 Cooking procedure**

#### **3.8.1 Deep-frying:**

The procedure for deep frying was performed according to Liao et al., (2010). Cooking oil was preheated in stainless steel deep-fat fryer until the temperature reach 180°C - 200°C. The samples was introduced into the cooking oil with controlled temperature at 180°- 200°C for 10 min, sample was turned every 2 min Core temperature of the sample at the end of cooking was 76°C ± 2°C. Temperature had been monitored with a thermocouple probe inserted into the centre of the sample.

#### **3.8.2 Boiling:**

The procedure for boiling methods was performed according to Siripon et al., (2007). A pot was used to cook the chicken breast. Sufficient amount of water for covering the chicken breast was putted into the pot. Water had been heated by an electrical heater at temperatures of 95 - 98<sup>0</sup>C before placing the chicken for cooking. Hot water temperature was controlled by a proportional controller. The samples were cooked in controlled temperature for 20min.

### 3.8.3 Roasting:

The procedure for roasting method was performed according to Conchillo et al., (2004). Oven was preheated at 220<sup>0</sup>C for 20 min. Then sample was put in the oven and hold at this temperature for 10 min on each side then the sample was removed from the oven when the internal temperature during roasting ranged between 95 – 100<sup>0</sup>C.

### 3.8.4 Grilling:

The procedure for grilling method was performed according to Lopez-Ferrer et al., (2001).Chicken breast was wrapped in to two layers of aluminium foil before grilling in a double-plated grill at 200<sup>0</sup>C. The internal temperature of edible portions was controlled, and sample was keeping inside the grill until an internal temperature of 85<sup>0</sup>C had been reached. The distance between samples and heat was about 8 cm. Time of cooking had been taken less than 15 min.

### 3.9 Proximate Composition Analysis of Chicken Breast

Proximate composition were conducted using Association of Analytical Chemists (AOAC, 1996) for moisture (Air-oven method), total ash, crude protein by nitrogen conversion factor of 6.25 (semi-micro Kjeldahl method) and crude fat content using the semi-continuous extraction (Soxhlet method). All measurements were carried out in triplicate (n = 3). Total carbohydrates were calculated by the formulas:

$$\text{Total carbohydrates} = 100 - (\text{g moisture} + \text{g protein} + \text{g fat} + \text{g ash})$$

#### 3.9.1 Determination of Moisture

In determination of moisture content, air-oven method or drying method (AOAC, 1996) was followed. In this method, a homogenous ground sample was dried in an oven (usually at 105 – 110°C) until constant weight was achieved. The difference between the initial weight and constant final weight after drying was considered as the moisture lost. Therefore, this different had been recorded as moisture content of the sample. .

### 3.9.2 Determination of Total Ash

Total ash in foods refers to the inorganic residue remaining after the organic matter has been burnt away at elevated temperature (around 550°C). Total ash content was determined by dry-ashing method, i.e. by incinerating a known quantity of dried food sample in a muffle furnace at temperature 500 – 600°C until constant weight was obtained (AOAC, 1996).

### 3.9.3 Determination of Crude Protein

The semi-micro Kjeldahl method (AOAC, 1996) was essentially used to determine the total nitrogen content of sample. The amount of nitrogen in the sample indicated the protein content of the sample after the amount of the nitrogen content was multiplied by a specific factor of 6.25 as most proteins contain 16% nitrogen.

In that method of analysis, the food sample was oxidized by heating with nitrogen-free concentrated sulphuric acid in a long neck digestion flask, in the presence of catalyst (usually copper sulphate, mercury, or selenium). Sodium or potassium sulphate was putted in to increase the boiling point of sulphuric acid. In this digestion process, nitrogen in the sample had been converted to ammonium sulphate. After that, the diluted digest was neutralized with concentrated sodium hydroxide solution (and if mercury is included in the catalyst, add sodium thiosulphate).