QUALITY CHARACTERISTICS OF QUAIL MEATBALLS

by

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CIRI-CIRI KUALITI BEBOLA PUYUH

Abstrak

Burung puyuh merupakan salah satu sumber penternakan selain daripada ayam. Walau bagaimanapun, penghasilan produk berasaskan daging puyuh tidaklah begitu popular. Dalam kajian ini, analisis nutrisi dan fizikokimia dijalankan ke atas dua jenis puyuh. Kajian ini turut menilai ciri-ciri kimia, fizikokimia dan sensori menggunakan empat jenis tepung sebagai pengikat (ubi kayu, jagung, gandum, sagu dan kentang). Ekstrak *Cosmos caudatus* (ulam raja), *Polygonum minus* (kesum), dan antioksidan sintetik hidroksitoluena berbutil (butylated hydroxytoluena, BHT) ditambah ke dalam formula bebola puyuh dan disimpan selama 21 hari. Kajian menunjukkan bahawa puyuh muda mempunyai kandungan protein yang tinggi berbanding dengan puyuh tua yang kandungan lemaknya adalah tinggi. Keputusan fizikokimia dalam daging puyuh muda menunjukkan bahawa kecerahan warna (L*) adalah tinggi berbanding dengan puyuh tua. Manakala warna kemerahan (a*) dan kekuningan (b*) adalah tinggi dalam puyuh tua. Nilai pH puyuh tua adalah lebih tinggi berbanding dengan puyuh muda. Nilai pH menunjukkan kolerasi positif dalam keupayaan pegangan air dan kolerasi negatif dalam nilai kecerahan (L*). Oleh itu, puyuh tua mempunyai keupayaan pegangan air yang tinggi, tetapi nilai kecerahannya (L*) adalah lebih rendah berbanding dengan puyuh muda. Kajian menunjukkan bahawa dalam bebola puyuh, tidak terdapat perbezaan yang signifikan ($p > 0.05$) dalam kalangan pengikat. Komposisi proksimat bebola puyuh menyamai bebola ayam yang dikomersialkan. Nilai pH, kecerahan, tekstur, hasil masakan, ketahanan lembapan, ketahanan lemak, dan ujian lipatan menunjukkan tiadanya perbezaan yang signifikan ($p > 0.05$) dengan jenis pengikat yang berbeza. Atribut sensori

produk akhir menunjukkan tiada perbezaan yang signifikan ($p > 0.05$) bagi warna dan bau. Perbezaan yang signifikan ($p < 0.05$) ditunjukkan dalam rasa dan tekstur. Penerimaan sensori secara keseluruhan menunjukkan bahawa formulasi menggunakan tepung ubi kayu adalah formulasi yang lebih baik dan adalah lebih diterima. Kajian bagi tambahan ekstrak *Cosmos caudatus* dan *Polygonum minus* menunjukkan kesan postif pada bebola puyuh walaupun kualitinya menurun mengikut tempoh penyimpanan. Dalam reaktif asid tiobarbiturik (thiobarbituric acid, TBA) dan analisis nilai peroksida, bebola puyuh yang dirawat dengan ekstrak *Cosmos caudatus* dan *Polygonum minus* menunjukkan hasil yang lebih baik berbanding dengan antioksidan sintetik (BHT). Dalam ujian lipatan dan analisis pertumbuhan mikrobial, tiada perbezaan yang signifikan ($p > 0.05$) ditunjukkan dalam rawatan antioksidan yang berbeza dalam bebola puyuh.

QUALITY CHARACTERISTICS OF QUAIL MEATBALLS

Abstract

Quail is one of the important sources of poultry meat besides chicken, but its usefulness for the production of meat products has not been popular. Nutritional and physicochemical analyses of young and spent of quail were conducted in this study. The study also evaluated the chemical, physicochemical, and sensory characteristics of quail meatballs prepared using different types of flour as a binder (cassava, corn, wheat, sago, and potato flour). Extracts from *Cosmos caudatus* (ulam raja) and *Polygonum minus* (kesum), and synthetic antioxidant Butylated Hydroxy Toluena (BHT) were added to quail meatballs formulation and stored for 21 days. The studies showed that young quail has high protein content than spent quail, while fat content was high in spent quail. The physicochemical data in young quail meat showed that lightness (L*) was higher in young quail, while redness (a*) and yellowness (b*) values were higher in spent quail. The pH value of spent quail was higher than young quail. The pH value had positive correlation with water holding capacity and negative correlation with L* value. Thus, spent quail meat has higher water holding capacity but has lower L* value compared to young quail meat. In the quail meatballs, the studies showed that there was no significant difference ($p > 0.05$) among binders. Proximate compositions of quail meatballs were similar to the commercial chicken meatballs. The pH, lightness value, texture, cooking yield, moisture retention, fat retention, and folding tests showed no significant differences ($p > 0.05$) with different types of binders. Sensory evaluation of final products shows that no significant ($p > 0.05$) differences for colour and odour. In overall sensory evaluation is show that the cassava formulation was one of the best formulations

produced and was the most acceptable. Studies on the addition of *Cosmos caudatus* and *Polygonum minus* extract showed positive effects in quail meatballs although quality decreases with longer storage time. For thiobarbituric acid (TBA) and peroxide value analysis, quail meatballs treated with *Cosmos caudatus* and *Polygonum minus* extract showed better results compared to synthetic antioxidant (BHT). For folding test and microbial growth analysis, results showed no significant differences ($p > 0.05$) among different antioxidant treatments of quail meatballs.

CHAPTER 1
INTRODUCTION

1.1 Background

Poultry provides an immense supply of food for the world's population. All over the globe, poultry meats and eggs are preferred than other kinds of animal food products for many reasons. It is estimated that 25% of the world's meat supply is derived from poultry and the proportion is increasing steadily. The trend has been more noticeable in developing countries in recent years (Prabakaran, 2003). The poultry sector of the global meat supply has experienced a dynamic growth in production, consumption and trade since the mid 1980's (Vink, 1999).

The research is focus on finding the potential of less popular meat to reduce dependency on dominant meat for commercial utilization, both in ruminant and non-ruminant meats. Poultry, a non-ruminant meat source, is usually dominated by chicken. Ostrich, turkey, duck, geese, quail are some of the non-chicken poultry meat which are still consumed in smaller quantity and also not widely available in every place of the world. The limited products from these meat sources are due to factors such as animal population, lifestyle, social, and religious factors. In the recent century, food products based on quail meat is limited due to the lack of information in modern processed meat product. The application of quail meat in modern processed meat product such as sausages, nuggets, meatballs, and burgers, hopefully will increase the demand for quail meat.

Increasing production of cut-up and processed meat has provided considerable quantities of parts that are suitable for mechanical deboning. This process is an efficient method of harvesting meat from parts left after hand deboning as well as from poor quality poultry. Mechanically deboned poultry meat (MDPM) is frequently used in the formulation of comminuted meat products due to its fine consistency and relatively low cost. The use of MDPM in nuggets, sausages, comminuted sausages, and restructured chicken products has been well documented (Perlo et al., 2006).

Meatballs are popular in Malaysia (Huda et al., 2010). Meats are usually used as the main ingredients in manufactured meat in a manufactured meat including meatballs. It's content should not be less than 65% in formulation according to the Law of Malaysia (2006). The essential ingredients that determined the quality of the meatballs are flour (starch), water and fat or oil. Most of Malaysian meatballs are manufactured by adding starch to provide desirable texture and to cut down the manufacturing cost. Non-meat ingredients, such as flour, starch, soya protein, eggs, whey protein and fat, play a significant role in the modification of functional properties, such as emulsification, water and fat binding capacity and textural properties of meat products (Gujral et al., 2002).

The oxidation of lipid is one of the basic processes that causes rancidity and leads to the deterioration of food products. It can occur during raw material storage, processing, heat treatment and the storage of final products. A taste or aroma that differs from what is expected can lead consumers to reject any kind of food (Karpinska et al., 2001).

Antioxidants have been used in the food industry to prolong the shelf life of foods, especially those rich in polyunsaturated fats. These fats are readily oxidized by molecular oxygen and the major cause of quality deterioration, nutritional losses, off-flavour development and discoloration. Various synthetic antioxidants have been used to retard the development of rancidity in meat products and thus, extend their shelf life (Aguirrezabal et al., 2000). The synthetic phenolic antioxidants propyl gallate (PG), Tert-Butylhydroquinone (TBHQ), butylated hydroxyanisole (BHA) and butylated hydroxytoluene (BHT) are frequently used to prevent oxidative rancidity in food, pharmaceutical and other commercial products (IARC, 1986). However, the use of synthetic antioxidants in food products has decreased due to their instability and their possible toxic and carcinogenic effects on health (Du & Li, 2008).

Although synthetic additives have been widely used in the meat industry to inhibit both lipid oxidation and microbial growth, there is growing concern among consumers about such chemical additives. As a result, food scientists have been searching for natural additives, especially of plant origin, that can be used as preservatives (Loliger, 1991). Compounds obtained from natural sources such as grains, oilseeds, spices, fruits and vegetables have been investigated (Chen et al., 1977). The development and application of natural products with both antioxidant and antibacterial effects in meat products are necessary to prolong their shelf life and prevent food borne illnesses.

1.2 Research Objectives

The objectives of this study are:

1. To determine the proximate composition, physicochemical properties, and nutritional quality of young and spent quail meat extracted by manual deboning versus mechanically deboning.
2. To determine the proximate composition, physicochemical properties and sensory acceptability of quail meatballs prepared with various types of flour.
3. To determine the effect of the addition of natural and synthetic antioxidants on shelf-life and physical properties of quail meatball during refrigerated storages.

CHAPTER 2
LITERATURE REVIEW

2.1 Poultry Meat Production and Consumption in the World and Malaysia

Figure 2.1 shows that since 2006 to 2009 the production of poultry in the world has increased. The main poultry meats produced were chicken and turkey. Poultry production in the world in 2009 has reached 79,044 metric tons. The major producing countries were USA, China, Brazil and EU-27. China and Brazil experienced faster growth rate in their poultry industry. The forecast for production in China and Brazil was 8 and 5 %, respectively. China's production has been accelerating since 2006 mainly due to the sharp decline in pork supplies (USDA-FAS, 2009) and the increase in the consumption of poultry meat in the world particularly from 2006 to 2009. In 2009 poultry meat production reached 76,138 metric tons (Figure 2.2). This shows that the demand and production of poultry is increasing every year throughout the world.

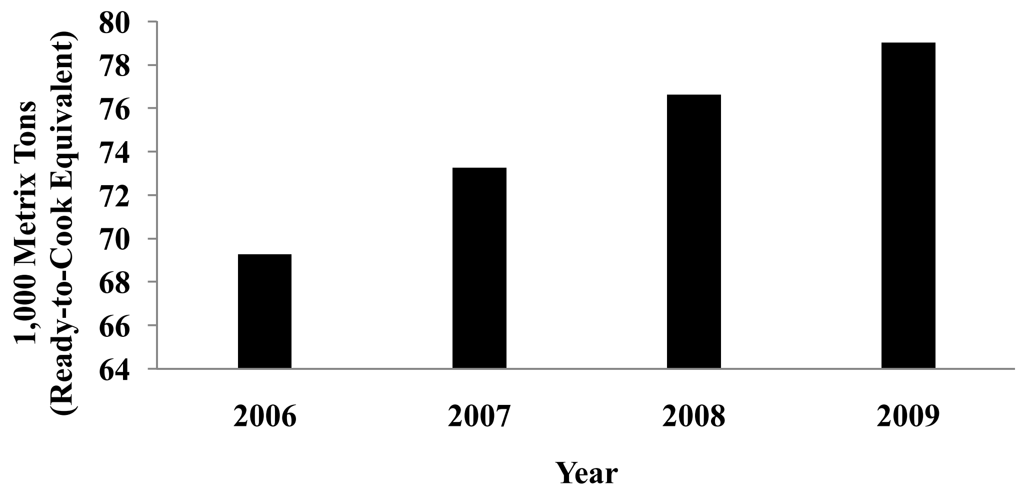

Figure 2.1 Production of Poultry Meat in the World from 2006 to 2009 (USDA-FAS, 2009).

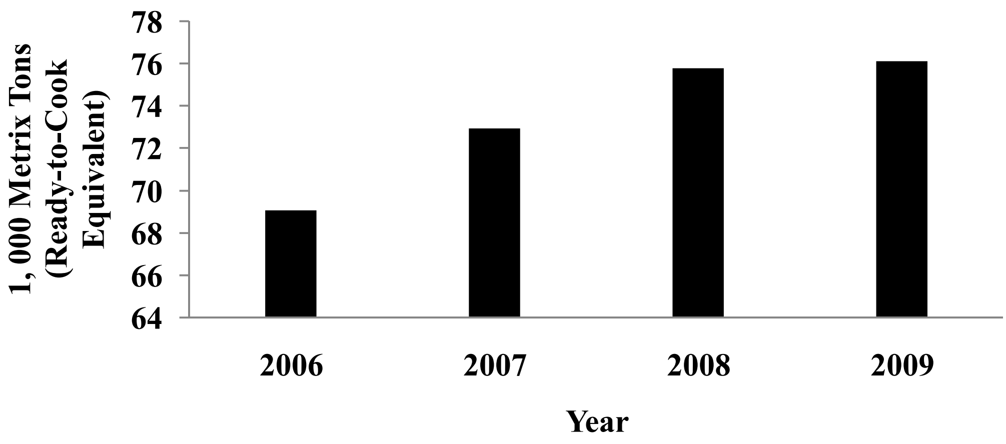

Figure 2.2 Consumption of Poultry Meat in the World from 2006 to 2009 (USDA-FAS, 2009)

Consumption of poultry meat per capita from selected countries is shown in Figure 2.3. The United Arab Emirates (UAE) was the highest (63.8 kg/person), followed by Kuwait (61.3 kg/person), United States (44.6 kg/person), Venezuela (39.5 kg/person), Brazil (39.0 kg/person), Malaysia (38.0 kg/person), Hong Kong (37.4 kg/person), Saudi Arabia (37.0 kg/person), Argentina (34.7 kg/person) and Australia (33.4 kg/person). Malaysia is the sixth highest in poultry consumption.

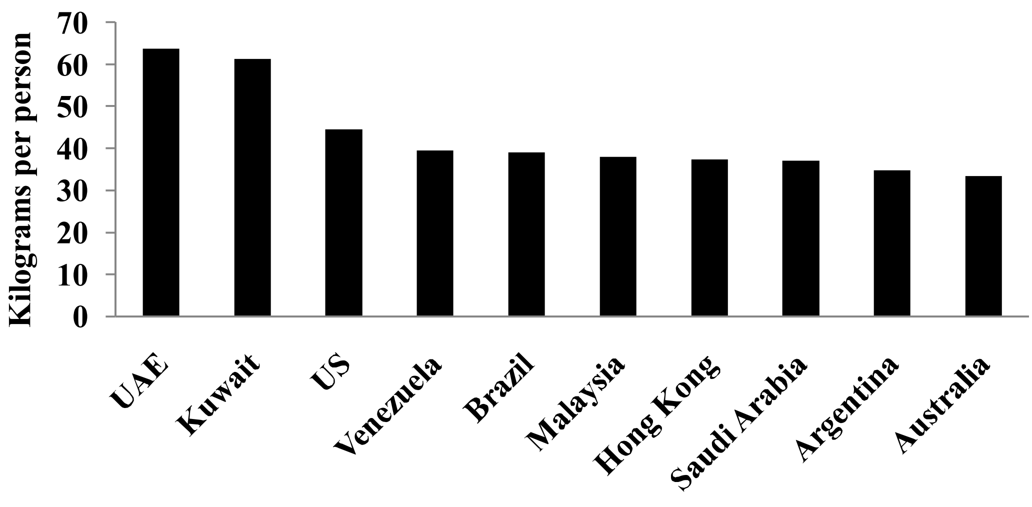

Figure 2.3 Consumption of Poultry Meat Per capita from Some Selected Countries (USDA-FAS, 2009)

The consumption of poultry in Malaysia reached 38.9 kg/person in 2007 (Figure 2.4). However, in 2008 and 2009 there was a reduction in poultry consumption in Malaysia. This may be due to a decrease in poultry production in two years. But the average consumption of poultry in Malaysia is the highest compared to other Southeast Asian countries.

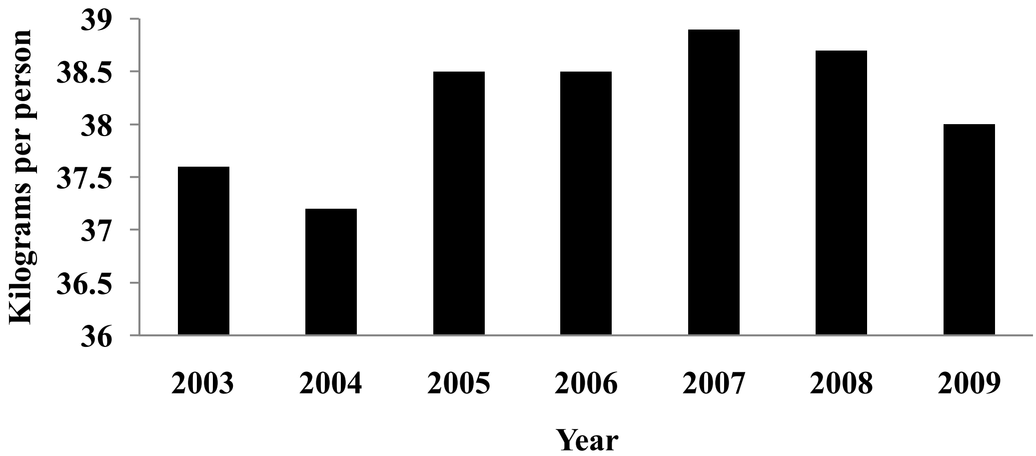

Figure 2.4 Consumption of Poultry Per capita in Malaysia (USDA-FAS, 2009)

2.2 Quails' Meat Production and Consumption

Quail rearing is rising in Malaysia as breeders boost output to meet high demand for the game bird. According to the East Coast Economic Region (ECER) secretariat, the demand for quails soared to 20 – 25% each year since 1995. The demand is not only in Malaysia but there is also an increased demand for quail meat at the international level. In Abu Dhabi, a quail farm produces 15,000 per week and soon has to increase the production to more than three times to meet customers' demand in the UAE alone. Agriculture quail aims to increase production to 50,000 per week and expects 200,000 quails per month by the end of this year (World Poultry, 2009a).

ECER has begun a project aimed at producing a new poultry bird, between cockerel and hen quail. Meanwhile, the Kuala Lumpur Veterinary Service Department has developed a strain that produces eggs of good quality and meat with the flavour of both parents (World Poultry, 2009a). The new bird is also intermediate in size between chicken and quail (World Poultry, 2009a).

In the world of poultry, quail meat production is negligible compared to broilers. Global profile of its production is quite different from the one of its larger relative (except for China). The sector does not seem to be experiencing any substantial and sustained growth, despite attractive marketing features of the meat. Yet quail meat is an interesting business (Da Cunha, 2008).

Quail eggs are more widely known, and more popular, than quail meat. Although this might not be true for all countries, the fact remains that quail meat is quite far from being a regularly consumed product. It is better seen and regarded as an exquisite food, a delicacy, or a meal for special occasions. France, Spain, Italy, China and the US are the largest producers, with other countries lagging. However, some initiatives to foster production were launched in places such as India, Australia and Canada. These regions are either trying to tap into some local advantages in production, or have an eye on a specific export market (World Poultry, 2009b).

According to World Poultry (2009b), China would once again be the largest meat producer. World Poultry (2009b) estimates that the country has around 80 million quail housed exclusively for that purpose. Figures for total meat production are not available. However, they are fed for 4 weeks before being slaughtered at a weight of 200 g. Using an approximation of 1,040 to 1,360 million birds being slaughtered per year (13 – 17 cycles/year), and a 70% carcass yield, we derived at a crude estimate between 146,000 and 190,000 tones being produced per year (Da

Cunha, 2008). In any case, their production is bound to be much higher than the next player (Figure 2.5).

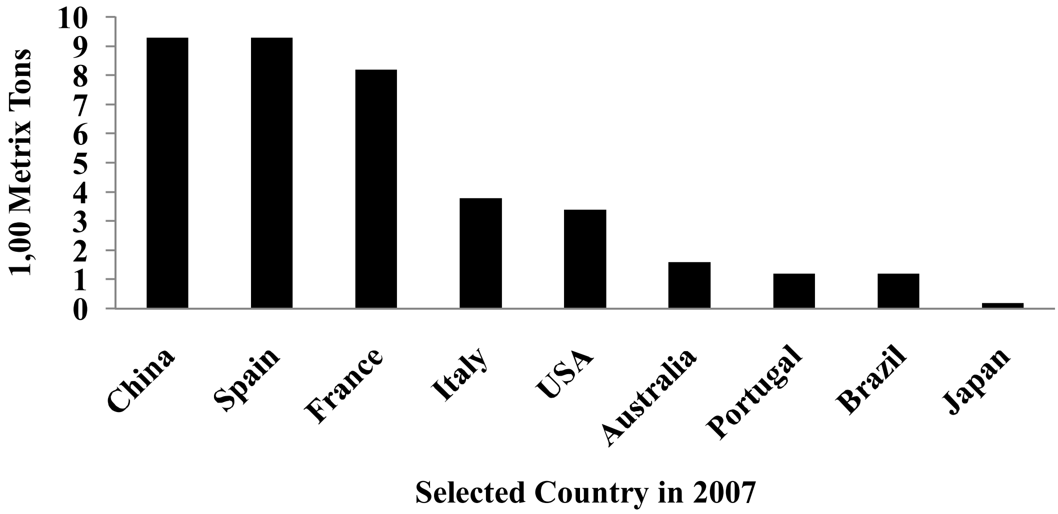

Figure 2.5 Production of Quails' Meat of Some Selected Countries in 2007 (World Poultry, 2009b)

Department of Veterinary Services Malaysia (JPH) report on quail meat production from 1996 to 2004 showed in Figure 2.6.

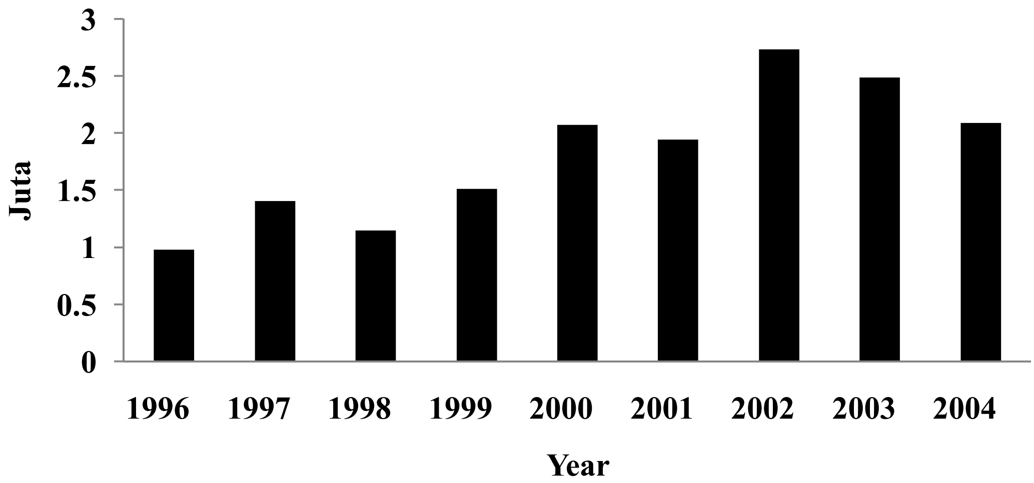

Figure 2.6 Quail Production in Malaysia (1996-2004) (JPH, 2006)

According to JPH (2006), quails' meat production reached 2.8 billion in 2002, and then experienced a decline in the next year to 2.5 million in 2003 and 2.2 million in 2004.

2.3 Quality Characteristics of Poultry and Quail Meat

2.3.1 Poultry meat

Poultry is a category of domesticated birds that people keep for their eggs, meat or feathers (Prabakaran, 2003). They belong to the super order, Galloanserae (fowl), the order, Galliformes (which includes chickens, quails and turkeys) and members of the family, Anatidae (in order Anseriformes), commonly known as "waterfowl" (e.g. domestic ducks and domestic geese) (Kleczek et al., 2006). Poultry also includes other birds that are killed for their meat, such as pigeons, doves or birds, and those considered as game birds, like pheasants. Poultry comes from the Latin word, poule, which means to hang. The term also refers to the flesh such as birds.

2.3.2 Nutritional quality and physicochemical characteristics of poultry meat

Nutrition value is the basic adjustment factor, but the physicochemical properties of meat, which include the water holding capacity, pH, cooking loss, colour and texture are also important factors in determining meat quality, the processors decision making and consumer quality traits. However, the price is also important for economic competitiveness and efficiency. Protein and fat are two important nutrients in meat and meat product. Poultry meat is a good source of protein. The few poultry meats that have high protein content are chicken, turkey and duck meat. Jaturasitha et al. (2008) found that the protein content of chicken breasts and thighs is 23.6 – 24.8% and 20.1 – 21.7%, respectively. Protein content of turkey breast and thigh is 25.0% and 21.0%, respectively (Maruyama et al., 1996) and duck breast and thigh are 20.8% and 19.6%, respectively (Cobos et al., 2000).

Muscle composition varies with increasing animal age irrespective of sex, breed or species. Research on various species has indicated that an increase in age is accompanied by an increase in intramuscular fat, increased saturation of intramuscular lipids, increased myoglobin concentration and increased in toughness due to changes in the nature of the connective tissue present in the muscle (Lawrie, 1991).

Quality is an important attribute affecting consumer reactions to poultry meat. White meat, including quail meat, is considered superior to red meat because it contains low fat content, low cholesterol and, high amount of iron (Jaturasitha et al., 2004). Determination of emulsification capacity (EC), water holding capacity (WHC) and cooking loss (CL) of various kinds of meat is very important for fresh meat and further processed products. In both cases, high yield and low cooking losses are desired.

WHC is known to be one of the major quality characteristics of fresh meat, as it affects some major characteristics of the cooked meat such as potential drip loss, technological quality, appearance and sensory properties (Van Oeckel et al., 1999). Low WHC of meat is undesirable for both retail consumption and manufacturing (Varnam & Sutherland, 1995). A useful way to determine quality changes during post-rigor stage is to measure the WHC of muscles.

The quality of poultry is determined by two extremely important traits, that is the appearance and meat consistency (Fletcher, 2002). According to Genchev et al. (2008) meat appearance depends on the colour of skin and meat, the presence of defects and this largely motivates consumer’s choice. Meat tenderness is more important in final quality determination. It depends on the thickness of muscle fibres and the ratio between the main metabolic types of muscle fibres forming muscle bundles.

Karakaya et al. (2005) concluded that CL is a very important factor for meat processors, as it directly affects eating quality and determines profitability. CL is affected by pH values of meat species and a high pH in muscle will improve the CL value. The quality of meat with regards to storage and processing depends on pH values and the water retention capacity (WRC) (Genchev et al., 2008).

The composition of amino acids determines the quality of protein in foods. In general, high protein foods are high in amino acids including essential amino acids (Kim et al., 2009). Amino acid data should be reported as mg amino acid/g N or be converted to mg amino acid/g protein by use of the factor 6.25. No other food specific protein factor should be used (Eggum, 1991). It is generally accepted that the nutritional quality of proteins depends on the content and availability of their essential amino acids (EAA) (Tuan et al., 1999). It is well accepted that the nutritional value of proteins may differ substantially depending on their essential amino acid composition and digestibility (Schaafsma, 2000).

The origin of animals, carcass characteristics and its meat quality are important criteria for butchers and consumers when it comes to making purchasing decisions. The fatty acid composition and cholesterol levels in meat have received increasing attention owing to their implications in human health and product quality. The ratios of polyunsaturated fatty acid (PUFA)/saturated fatty acid (SFA) and n-6/n-3 PUFA, and hypocholesterolaemic/hypercholesterolaemic (h/H) are widely used to evaluate the nutritional value of fat (Orellana et al., 2009).

Quail is one of the leanest type of poultry and a good source of protein and minerals such as sodium, potassium and iron. Important PUFA's of meat include the essential fatty acids, linoleic acid (C18:$2n-6$) and α-linolenic acid (C18:$3n-3$), as well as C20 and C22 PUFA's that are present in phospholipids (Enser et al., 1996).

2.3.3 Hand deboned poultry meat (HDPM) and mechanically deboned poultry meat (MDPM)

Mechanical deboned meat (MDM) is the residual meat remaining on the frames, necks and backs of hand deboned or automated-cut poultry and is usually harvested by the so-called mechanical deboning equipment. For future developments, the equipment can also be used for deboning whole spent hens or meat from parts that would not yield high-priced meat and justify the cost of hand deboning (Barbut, 2002).

When high-priced muscle from an animal is removed, inedible, relatively hard or components such as bone, gristle, and tendons, remain on the carcass. Thus, mechanically recovered or separated meat are generic terms used to describe residual meat that has been recovered or separated by the application of pressure or shear force to animal bones or poultry carcasses from which the bulk of the meat has been removed (Crosland et al., 1995). This permits the recovery of most of the residual meat, which would otherwise be difficult or uneconomical to acquire (Day & Brown, 2001).

The consumption of poultry meat and poultry meat products continues to grow and the increased production of cut-up and processed meat has provided considerable quantities of part suitable for mechanically deboning (Perlo et al., 2006). This process is considered an efficient method of harvesting meat from the parts left after hand deboning as well as from poor-quality poultry (Viuda-Martos et al., 2010). Increased production of the cut-up and processed meat has provided considerable quantities of parts suitable for mechanical deboning. This process is an efficient method of harvesting meat from the parts left after hand deboning as well as from poor quality poultry.

Mechanical deboning involves grinding meat and bone together, and forcing the mix through a fine screen or slotted surface to remove bone particles. According to the current Brazilian law (Instrucao Normativa, 2000 in Daros et al., 2005), MDM is defined as meat which has been obtained by mechanical processing, chopping and separation of bones from animals, such as chicken, beef and pork, to be used in the formulation of specific meat products. It is also stated that only bones, carcasses or parts of carcasses, which have been approved for human use by the Brazilian Federal Inspection Service (SIF) should be used, thereby excluding head, feet and legs.

The chemical composition of MDPM is subjected to an extremely wide variability and depends on species, breed, and age of the animal as well as the carcass parts used, the proportion of bone and fat in the material being deboned, the degree of trimming, and the machine type and setting (Henckel et al., 2004). Yields of MDPM range from 55 to 80% depending on the part deboned and deboner settings (Mielnik et al, 2002). MDPM is frequently used in the formulation of comminuted meat products due to its fine consistency and relatively low cost. The protein content in MDPM varies from 11.4 to 20.4% depending on material being deboned (Field, 2004). The proximate composition of chicken MDM has been investigated by Al-Najdawi and Abdullah (2002). They found that moisture content of chicken MDM ranged from 69.85 to 70.95%; protein, 20.35 to 20.45%; fat, 7.55 to 9.15% and 0.32 to 1.25% for ash in wet basis.

The resulting MDPM appearance is finely comminuted, thus, MDPM is used in a wide range of emulsified meat product and, in smaller proportion, in non-emulsified meat product such as restructured chicken product. The use of MDPM in frankfurters, kamaboko-like products, nuggets, sausages, restructured chicken products and mechanically deboned chicken meat is well documented (Lin & Chen, 1989). Other studies have shown that the quality of further processed products containing MDPM is affected by the specific parts of carcasses used (Pizzocaro et al., 1998). Many differences have been documented for various types of MDM such as colour stability (Demos & Mandigo, 1996), mineral, vitamin and cholesterol content (Al-Najdawi and Abdullah, 2002) and lipid oxidation (Mielnik et al., 2002). Comparison of bone content in hand deboned meat (HDM) and MDM by Demos and Mandigo (1996) revealed that MDM has a higher ash and Calcium content, signifying greater bone content than HDM (Al-Najdawi and Abdullah, 2002).

2.3.4 Quail meat (*Coturnix japonica*)

The Japanese quail (*Coturnix japonica*) is shown in Figure 2.7. The taxonomic classification of Japanese quail in the animal kingdom, according to Myers et al. (2006), can be grouped in the genus, Coturnix and species *Coturnix japonica*. Basically, the scientific taxonomy of Japanese quail is as follows:

Kingdom : Animalia

Phylum : Chordata

Subphylum : Vertebrata

Class : Aves (birds)

Order : Galliformes

Family : Phasianidae

Subfamily : Perdicinae

Genus : Coturnix

Species : *Coturnix japonica*

Figure 2.7 Japanese quail (*Coturnix japonica*)

In general, Japanese quail inhabits parts of Russia and eastern Asia, including Japan, Korea and China as well as India. The quails spend winter in China, Southeast Asia, the extreme northwestern coast of Africa, and a sub-Saharan band north of Congo and including the Nile River valley from Egypt to Kenya. A small population has been found in Angola. Races of this quail are found in Kenya, Tanzania, Malawi South to South Africa, Mozambique, and Namibia as well as parts of Madagascar (Pappas, 2002). These quails may breed in parts of Europe, Turkey, and central Asia to parts of China.

The Japanese quail is similar in appearance to the European Common Quail (*Coturnix coturnix*). Overall, they are dark brown with buff mottling above and lighter brown underneath. They have a whitish stripe above the eye on the side of the head. Legs are orangish-gray to pinkish-gray as is the beak. In contrast to the males, females usually (but not always) lack the rufous coloring on the breast and black flecking or markings on the throat (Pappas, 2002).

There are variations in plumage colour. Some birds are whitish to buff with rufous to chestnut mottling above. Others have a very dark brown appearance with little to no mottling. In addition, there have been golden-brown varieties bred in captivity. Wing size in males and females are similar and ranges from 92 to 101 mm.

Both male and female have similar sized tails ranging from 35 – 49 mm in length (Pappas, 2002).

Generally, quails are small-to-medium sized birds, belonging to the same biological family of chicken and pheasants (*Phasianidae*), taken into consideration the overall similarity in physical characteristics and behaviour. Quails, most commonly bred for human consumption, belong to the species *Coturnix japonica*. Their distribution in the wild spreads over large areas of Asia, Europe and Africa, but they were first domesticated in Japan (Mizutani, 2003). According to Mizutani (2003), they were initially kept for their singing abilities. It was for this reason that they were seen more as pets. Only in the beginning of the 20th century did commercial production begin in Japan. From there it spread first to China and soon after to Europe. Quail meat has been known for centuries, and there are even biblical quotations of their use as a meat source.

In recent years quail meat has been gaining much popularity among consumers. Japanese quails are replacing broiler chickens due to high nutritive value and medical properties. Quail meat has less fat, less calories and an ideal food for health conscious consumer. Quail meat and eggs are renowned for being rich in vitamins, essential amino acids, unsaturated fatty acid and phospholipids, which are vital for human physical and mental development (Wahab and Poultry Breeding Research Centre, 2002).

2.3.5 Nutritional quality and physicochemical characteristics of quail meat

Quails have certain distinct characteristic that makes them suitable for both eggs as well as meat production. These characteristics include early marketing age (five weeks for meat purposes, which is slightly below six weeks for broiler chicken), early sexual maturity (requires only six to seven weeks of age to produce eggs) and high laying rate (280 eggs per year). Besides these, they require a small space for their rearing. For example, eight to ten birds can be kept in the same space housing a single chicken.

Quail meat, like ostrich, partridge, and several other meats, belongs to the group of specialty or luxury poultry products. Quail eggs are a bit more popular, but not as much as those of chickens. Both are special niche products of interest and of relative importance for some countries (Da Cunha, 2008). The Proximate composition of quail muscles is presented in Table 2.1.

Table 2.1 Proximate Composition of Breast and Thigh Muscles of Japanese Quail

	35 day old[1]		45 day old[2]	
	Selected	Unselected	Male	Female
Breast muscle (%)			Breast muscle (%)	
Dry matter	26.4	25.7	27.51 ± 0.30	26.92 ± 0.07
Protein	22.5	23.4	23.38 ± 2.14	22.23 ± 3.02
Fat	2.7	1.4	2.21 ± 0.22	2.75 ± 0.18
Ash	1.5	1.4	1.51 ± 0.10	1.61 ± 0.08
Thigh muscle (%)			Legs muscle (%)	
Moisture	24.9	24.6	26.50 ± 0.13	25.86 ± 0.11
Protein	21.1	21.3	20.49 ± 2.27	20.91 ± 0.13
Fat	3.2	2.5	3.39 ± 0.11	3.26 ± 0.37
Ash	1.1	1.1	1.64 ± 0.06	1.62 ± 0.90
Carcass (g)	185.1	109.4	64.97 ± 0.30	64.03 ± 0.52
Breast (g)	40.4	23.4	20.80 ± 0.77	20.30 ± 1.53
Thigh (g)	21.2	13.4	16.63 ± 0.20	15.97 ± 0.22
Legs (g)	-	-	12.62 ± 1.41	12.06 ± 1.29

[1]Caron et al. (1990)
[2]Genchev et al. (2008)

Quail meat is renowned for its low caloric value in addition to having high quality protein of high biological value (Haruna et al., 1997). Olubamiwa et al. (1999) indicated that qualities especially the low fat content, are likely to divert the attention of people especially the hypertensive-prone individuals to quail consumption. Quail meat tissues are good sources of fatty acid, SFA, MUFA, PUFA, ω3, and ω6, as shown in Table 2.2.

Table 2.2 Fatty Acid Composition of Muscle Tissue Quail Meats (%)

Fatty acid	Muscle tissue[1]	Breast[2]	Leg[2]
C14:0	0.25 ± 0.02	0.95 ± 0.04	1.17 ± 0.06
C16:0	17.50 ± 0.62	24.39 ± 0.71	24.54 ± 0.48
C16:1ω-7	3.96 ± 0.38	5.32 ± 0.48	6.05 ± 0.54
C18:0	18.31 ± 0.60	8.79 ± 0.47	8.01 ± 0.52
C18:1ω-9	16.50 ± 1.23	35.38 ± 1.43	35.52 ± 1.15
C18:2ω-6	20.33 ± 0.34	19.70 ± 0.58	20.21 ± 0.71
C18:3ω-3	0.65 ± 0.06	1.75 ± 0.22	1.47 ± 0.10
C20:3ω-6	0.71 ± 0.02	ND	ND
C20:4ω-6	11.14 ± 0.64	2.69 ± 0.31	1.94 ± 0.15
C20:5ω-3	0.56 ± 0.03	ND	ND
C22:4ω-6	0.47 ± 0.06	0.84 ± 0.08	0.87 ± 0.07
C22:5ω-6	0.58 ± 0.01	ND	ND
C22:5ω-3	0.76 ± 0.07	ND	ND
C22:6ω-3	8.36 ± 0.77	ND	ND
Σ Saturated	36.06 ± 0.43	34.13 ± 0.90	33.72 ± 0.80
Σ Unsaturated	63.64 ± 0.30	65.68 ± 0.89	66.04 ± 0.79
Σ MUFA	20.46 ± 0.76	40.70 ± 1.27	41.57 ± 0.92
Σ PUFA	43.16 ± 0.25	24.98 ± 0.53	24.48 ± 0.72
Σ ω-3	10.33 ± 0.24	1.75	1.47
Σ ω-6	33.23 ± 0.22	23.22	23.02

[1]Yilmaz et al. (2008)
[2]Genchev et al. (2008)

Characteristics of adult quails are weight 300 g, sexual maturity is 42 – 48 days, lays up to 290 eggs/year with egg weight between 9 – 10 g, have a life span between 3 – 4 years and a carcass yield around 75-78% (Mizutani, 2003). Physiological characteristics analysis of Japanese quail presented in Table 2.3.

Table 2.3 Physiological Characteristics Analysis of Japanese Quail (*Coturnix japonica*)

No	Physiological characteristics	Value		References
1	live weight at slaughter (g) chilled carcass weight (g) chilled carcass yield (%) hot carcass weight (g) hot carcass yield (%)	158.40 ± 1.97 120.20 ± 1.47 75.91 ± 0.60 116.00 ± 1.42 73.26 ± 0.70		Avci et al. (2007)
2		Male	Female	Eren et al. (2006)
	dry matter (%) fat (%) ash (%) hot carcass yield (%) cold carcass yield (%)	25.77 ± 0.42 1.79 ± 0.22 0.93 ± 0.01 73.82 ± 1.87 72.21 ± 1.44	25.80 ± 0.33 1.91 ± 0.18 0.95 ± 0.02 68.48 ± 3.02 66. 73 ± 2.81	
3	slaughter weight (g) carcass yield (g) carcass yield (%)	178.23 ± 2.53 123.92 ± 2.58 69.57 ± 3.65		Ozbey et al. (2004)
4	live weight	227.06 ± 3.20		Uyanik et al. (2008)
5	carcass weight (g)	156.9		Karaman et al. (2009)
6	slaughter weight (g) hot carcass weight (g) hot carcass yield (%)	181.40 ± 2.27 128.04 ± 1.15 70.58 ± 0.46		Seker et al. (2009)
7	live weight at slaughter (g) hot carcass yield (%) chilled carcass yield (%)	156.40 ± 1.83 76.98 ± 0.86 74.29 ± 0.71		Denek et al. (2007)
		Male	Female	Sahin et al. (2008)
	body weight (g) carcass weight (g)	144.50 ± 2.62 99.65 ± 2.24	142.04 ± 2.80 95.63 ± 2.18	
8	Average:	Male	Female	Alkan et al. (2010)
	body weight (g) carcass weight (%) carcass yield (%)	163.28 116.01 71.2	198.06 125.14 63.1	

Shanaway (1994) stated that broiler quails are slaughtered at about six weeks of age. The old breeding birds (8 weeks) are also slaughtered and sold in the market without any distinction on age. This has led to a number of incidences where wholesalers and retailers have had problems with meat quality specifically, since the meat derived from the older birds appear darker and is apparently tougher upon consumption after cooking.

2.4 Industries of Meat Product Processed in Malaysia

Meat processing technologies have been developed in Asia as well as in Europe. However, the European techniques are more successful, as proven by the dissemination and adoption of their technologies by other world regions (Heinz & Hautzinger, 2007). Currently, many types of meat products are easily found all over the world, including meat products based on poultry meat. The diversification of meat product has been developed in many forms, such as in substitution of meats, binders, and spices with other potential components.

Poultry meat processing industry is an industry that produces various products such as meatballs, sausages, burgers, nuggets etc. This industry has the potential and is growing very fast. In Malaysia, the poultry meat processing industry is growing rapidly, as much as 20% of the total poultry produced are processed into meat products (Babji, 1997).

The development and growth of processed meat industry in Malaysia is heavily influenced by state intervention in pricing as part of the control (Babji, 1997). Changes in lifestyle and way of eating have contributed to high demand for processed meat products. In addition, various incentives in the form of venture capital, technology and new inventions which have been made available have helped the development of processed meat industry in Malaysia. This industrial development in the future will depend much on new discoveries through investigations, the development and use of advanced technologies to minimize time and cost.

There are a number of local companies such as Malayan Flour Mill (Ayam Dindings), KFC Holdings (Ayamas), Sin Mah (Farm Best), FIKA Food Sdn. Bhd. and Ramli Sdn. Bhd involved in the slaughtering and processing of poultry meats. For example, Dindings Poultry Processing Sdn. Bhd. farm slaughters approximately 35,000 – 45,000 chickens per day. From that amount, as much as 15 – 25% of chicken is processed further into value-added products, chicken meatballs contributed approximately 12% of the total value-added products produced. In 1998, four firms were bound entirely within the process of integration and expenditure of the products of KFC Holdings Sdn. Bhd., Dinding Poultry Processing Sdn. Bhd., Leong Hup Sdn. Bhd. and Sin Mah Holding Sdn. Bhd. In Thailand and Malaysia, processing continues to increase, and nearly 20% of chickens slaughtered are processed into meatballs, nuggets, sausages and burgers (Babji, 1998). Malaysia has one of the highest per capita consumption rates in the world for chicken. About 30% of broilers are channelled through modern processing plants, 60% are sold as dressed birds in market. Quick-service restaurants based on processed chicken products are popular in Malaysia. Further-processed products are also distributed to wholesalers, supermarket, hypermarkets, catering institutions, restaurants, and hotels (Guirrero-Legarreta & Hui, 2010).

Due to a number of possible processing methods, poultry products are available to the consumer in a wide range of products. Poultry products can be classified in various ways, depending on the specific objective of the food item, degree of comminuting, processing characteristics, shelf-life expected and particular specifications (e.g., low fat). Consumer acceptance of meat product depends on its quality, which is influenced by a series of factors ranging from the physical and chemical to the histological properties and processing procedure of meat (Alvarado & Sams, 2004). There are some important factors influencing the choice of meat and meat products by consumer. These factors include fat content, production of leaner animals, appearance factors (visible fat), development of low fat meat product (low fat formulation, demographic influences (income, age, ethnicity, convenience, and change in distribution) and new product development (restructured meat products, low-salt products, vacuum-packaged meat products) which are related to health issues (Resurreccion, 2003).

Non-chicken poultry meat has been studied by several researchers; research has been undertaken on quail meat (Genchev et al., 2008), ostrich meat (Hoffman et al., 2008) and goose meat (Wezyk et al., 2003). However, current data is not available regarding the utilization of quail meat into processed meat products.

2.5 Meatballs

Meatballs are popular meat product in Malaysia. The types of meatballs in Malaysia include, chicken ball, fish ball, beef ball, prawn ball and squid ball. Beef, chicken, and fish are the dominant components in meatballs sold in the market. However, in order to diversify meatball products and to improve other meat consumption in the society, other potential meat such as quail and duck can be used. Most of Malaysian meatballs are manufactured by adding starch to provide the desirable texture and also to cut down the manufacturing cost.

Some studies were done to determine the quality, chemical composition and physicochemical properties of meatballs. Such studies include the effect of ingredients on fish ball (Yu & Yeang, 1993), the effect of rice brain on sensory and physicochemical properties of emulsified pork meatballs (Huang et al., 2005), and a quality of low-fat meatballs containing legume flour as extender (Serdaroglu et al., 2005).

2.5.1 Processing and ingredients of meatballs

In order to increase product acceptability, various processes and ingredients have been used. Non-meat ingredients, such as soya protein, egg, cereal flours, starch, whey protein and fat, play a significant role in the modification of functional properties, such as emulsification, water-binding capacity, fat-binding capacity and textural properties (Gujral et al., 2002).

Particularly, non-meat proteins and carbohydrates are often used to enhance the texture of meat products (Hongsprabhas & Barbut, 1999). Soy protein as an emulsifier and stabilizer has the ability to increase WHC and improve texture of final products (Macedo-Silva et al., 2001). Table 2.4 shows the various processes, ingredients and their effects on quality of meatballs as published by many researchers.

Table 2.4 Effect of Processing Factors and Ingredients on Quality of Meatballs

Type of processing factor	Effect on quality of meatballs	References
Interaction effect of water, phosphates, salt and fat	Increasing addition of water significantly increases cooking loss and decreased moisture and protein content Increasing addition of phosphates significantly decreases cooking and lipid content Interactions of phosphates with salt significantly effect for cooking loss Interaction of phosphates with fat, salt with fat, and water with fat significantly effect lipid content Increasing water addition significantly decreases product hardness Increasing phosphates significantly increased cohesiveness, elasticity and viscosity Increasing fat addition increased *L* (lightness) value, increasing phosphates addition decrease *a* (redness) value, and interactions of phosphates with salt significantly effect for *b* (yellowness) value Increase in phosphate and salt significantly increase most of quality preference score, texture score increased with less added-water	Hsu and Yu (1999)
Ingredient	Polyphosphates significantly decreased cooking loss and significantly improve textural qualities	Chen and Guo (1985)
Ingredient	Phosphates enhance WHC and improve the binding and cooking yield Phosphates and combination with salt greatly enhance WHC	Sofos (1986)
Processing factor and ingredient	Higher salt addition significantly decreased cooking loss and lipid content Increasing fat addition significantly decreased moisture and protein content and increasing lipid Concentration ratio decreased the moisture and protein concentration ratio Increasing water addition level significantly decreased moisture and protein content Increasing phosphates significantly increased cohesiveness, elasticity and viscosity Hardness, chewiness, and gumminess significantly increased with decreased fat addition Fat addition and cooking temperature significantly affected viscosity product Increasing fat addition increased *L* (lightness) value Cooking temperature, salt, sugar addition and their interaction significantly effect the odour Higher salt addition significantly increased product acceptance and texture	Hsu and Chung (1998)

Figure 2.8 shows the general process of meatballs. Firstly the ingredients were prepared for the processing of meatballs. The ingredients were weighed in the right percentage due to the formulation. The raw meat was cut into smaller pieces by using Meat Bone Saw Powerline Machine, USA. The ingredients were then mixed and ground using Robot Coupe Blixer Grinder for only 2 – 3 minutes because as this will increase the temperature and high temperature will cause denaturation of protein in the meatball. The water used in the mixture is cold water for the same reason. Next, the blend is shaped into a ball shape in equal sizes manually. The shape of meatballs were retained by immersing in water at 40ºC for 20 minutes then cooked at 90ºC for another 20 minutes (Yu, 1994). The samples were then cooled in room temperature before an analysis is conducted.

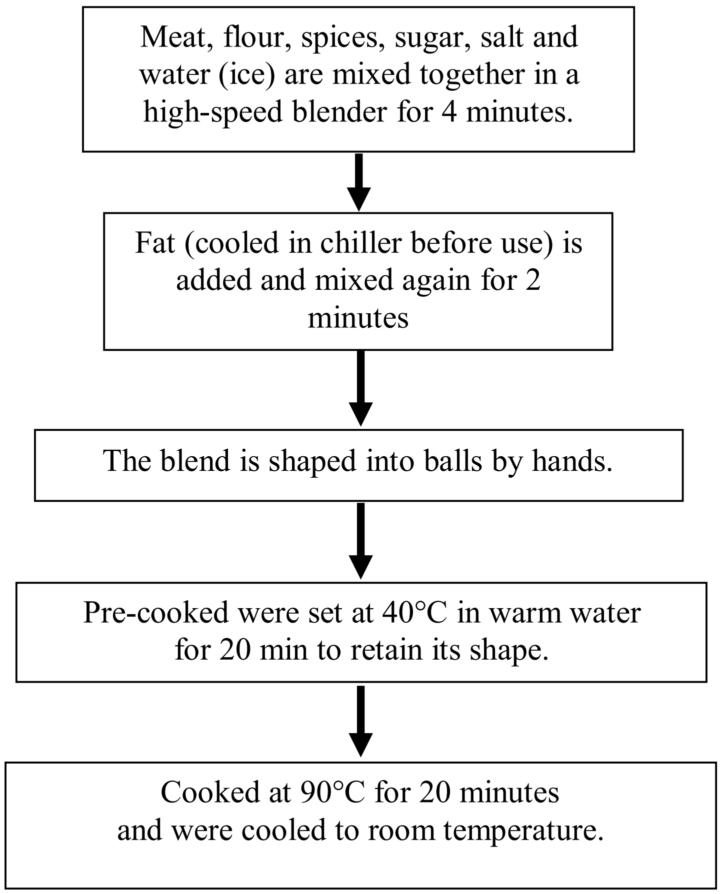

Figure 2.8 Flow Chart for Meatball Processing