Chapter 2

Review of Literature
2.1. BEEF

Since the beginning of the diet and health craze of the 1980’s, the contribution of beef to the diet has been a controversial and perplexing subject to the greater proportion of people in the world. Health professionals have often labeled beef as fat and unhealthy, especially when compared to other meat choices. Consumers have been discouraged to eat red meat, especially beef, by health professionals who believe diets high in saturated fat contribute negatively to risk factors associated with coronary heart disease. However, for many years, there have been nutritional information sources that have misled both nutritionists and the consuming public about beef’s role in the diet as a source of dietary fat. In India, there is very limited research carried out on carcass composition and meat quality. So we need to study the effects of different factors in Indian conditions on carcass composition and meat quality of food animals (Irshad et al. 2012).

The Indian zebu cattle (*Bos Indicus*, thoracic humped cattle) originated from India and later spread to South East Asia and other countries (Maule, 1990). This cattle type is typically quite light (adult males weigh 300–350 kg, females 200–270 kg), heat tolerant, disease resistant and fertile (Wannapat, 2004). They are often used as draught animals especially in rice fields. After field discharge they are sold and later slaughtered. Beef is the terms used to define the meat bovines, especially of domestic cattle (like cows). Beef carcass and cut composition has been a longstanding research area for meat scientists. Studies conducted to predict the estimated yields of retail cuts from beef carcasses date back to as early as the 1960’s (Murphey et al., 1960). Calorie-for-calorie, beef is one of the most naturally nutrient-rich foods. On average, a 3 oz. serving of lean beef provides about 150 calories and an excellent source of six nutrients (protein, zinc, vitamin B12, vitamin B6, niacin, and selenium) and a good source of four nutrients (phosphorous, choline, iron and riboflavin)(USDA, 2010). Beef is an important source of protein, monounsaturated fatty acids, conjugated linoleic acid, vitamins and minerals (Acheson, 2013). Research shows lean beef can be good for heart health. The Beef in an Optimal
Lean Diet (BOLD) study demonstrated that eating lean beef, as part of a heart-healthy diet and lifestyle, can lower LDL (bad) cholesterol by up to 10%, as much as any other recommended heart-healthy diet (Roussel et al., 2012). Consumption of beef, regardless of the feeding system, provides an excellent source of zinc, vitamin B12, and selenium, and a good source of vitamin B6 and iron (USDA, 2006). Additionally, an analysis of the dietary sources of nutrients of American adults from 1994 to 1996 showed that beef was the most common source of 25 protein in the diet, comprising approximately 17% of total protein into the diet (Cotton et al., 2004).

The longer term theme of increasing global meat demand remains intact, driven by population growth and rising per capita meat consumption in developing nations. Global meat consumption grew at an annual average rate of 2.7% from 1970 to 2007. The beef industry, which was once the world’s dominant livestock industry, has lagged the growth in other meat sectors in recent decades. Pork overtook beef as the world’s most commonly consumed meat in 1978 and chicken claimed second position in 2000. Beef demand has been sluggish while ‘white’ meat consumption has surged. Over 80% of global meat consumption growth since 1970 has been in ‘white’ meat categories. Global beef demand has fallen for the past five years. In 2010 and 2011 global cattle numbers fell to their lowest level since the mid-1990s and total slaughter declined to the lowest level in a decade. It was predicted that the global beef consumption will fall by 92 thousand tonnes to 55.6 million tonnes in 2012 according to the USDA, the fifth consecutive annual decline, as consumers continue to favour chicken and pork. Beef consumption has been steadily declining over the last two decades mainly due to problems with consistency of quality (i.e., tenderness), perceived health-fulness (i.e., lipid amount and composition), and food safety (i.e. E.coli, bovine spongiform encephalopathy)(Mandell et al., 1998).

2.1.2. BEEF CARCASS CHARACTERISTICS

2.1.2.1. Effect of breed on carcass characteristics

Meat animal carcasses vary in composition through genetic, age and sex of animal, nutritional, and environmental effects. Carcass composition of various species differs considerably in terms of carcass weight, percentages of fat, muscle and bone. The growth
and carcass composition traits differ between breeds within all farm animal species. As an animal matures, it undergoes an increase in the ratio of muscle to bone, followed by a decrease in muscle growth rate and an increase in the ratio of fat to muscle (Lawrie, 1998). In beef cattle, late-maturing breeds, such as the Continental European breeds, are often preferred under conditions of good nutrition, producing heavier carcasses with little fat. Early maturing beef breeds, such as the traditional British breeds (e.g. Angus, Hereford, Shorthorn), can be slaughtered at lighter weights and may be preferred when food supply is limited or for certain markets (Kempster et al., 1986). Several production and biological factors, such as differences in management, nutrition, age and genetic background are considered responsible for the large variation in beef quality (Delgado et al., 2005). While breed and slaughter age influence live-weight and carcass traits significantly, age at slaughter, which is the product of age as well as the environment, has a much more pronounced influence on meat quality traits than breed, possibly the result of the combined effects of fatness, pH and collagen characteristics (Du Plessis and Hoffman, 2007). Breed-specific differences in growth rate can affect carcass weight (Vieira et al., 2007). Xie et al (2012) reported that the two European cattle breeds, Limousin and Simmental, had better growth performance, gain efficiency, carcass weight, net meat weight, rib-eye area and yield index than the local breeds at the same age under the typical Chinese beef production system.

Barton et al (2006) observed significant breed differences in growth, slaughter and carcass traits in 4 selected breeds of bulls. Charolais and Simmental gained live slaughter weight more rapidly (p<0.05) than Aberdeen Angus while Hereford was intermediate. The percentage of Grade I meat was also higher (p<0.05) in Charolais and Simmental. The later maturing bulls generally tended to achieve higher live weight gains during the experiment, produced less fat and had higher percentage of meat from high priced joints in comparison with earlier maturing animals.

Similar study by Oprzadek et al (2001) also concluded that the carcass weight (312.4 kg) was highest in Charolais bulls but the highest meat yield in valuable cuts (71.6 kg and 77.1%) and the lowest share of separable fat (8.9%) were recorded in Limousin though all the bulls were fattened under identical condition. Meat animal carcasses vary in composition through genetic, age and sex of animal, nutritional, and
environmental effects. Carcass composition of various species differs considerably in terms of carcass weight, percentages of fat, muscle and bone.

2.1.3. NUTRITIONAL PROFILE

2.1.3.1. Proximate composition

U.S.D.A (1966) calculated that beef muscle contains 67% and 51.9% moisture, 19.5% and 29.9% protein, 12.7% and 17.6% fat and 0.8% and 1% ash in raw and cooked conditions respectively. Adeniyi et al (2011) found that Nigerian beef contains 22.75% Crude Protein, 4.59% Ether Extract, 0.41 % Ash and 2.25% Nitrogen Free Extract on dry matter basis. The Protein, Fat, Ash and Moisture content of longissimus dorsi chuck of Arsi breed cattle were 22.1, 6.9, 0.99 and 0.04% respectively (Gebeyehu et al., 2013).

Seggern and Calkins (2005) studied the beef chuck and round muscles and found the average pH, fat, moisture and ash as 5.78 ± 0.32, 6.86 ± 3.45, 72.28 ± 2.83 and 1.26 ± 0.28. and as the muscle pH increased, the expressible moisture content decreased.

McCurdy et al (2006) reported that breed-type had minimal effect on proximate composition of beef muscle but the feeding regime affects significantly. Johnson (2000) reported that age has a greater influence on carcass composition than breed type of the animal. Chambaz et al (2002) found that fat content in beef muscle is significantly influenced by cattle genotype. Pogorzelska et al (2013) revealed significant (p<0.05) differences in protein and fat content among the muscles of different bulls of Limousine, Charolais and Hereford bulls. Gebeyehu et al. (2013) reported that the moisture content of longissimus dorsi varied from 68.44% to 72.47% due to age and production system difference which was in agreement with the report of Patten et al. (2008). Bures et al. (2007) reported that protein fat, ash and moisture content significantly varies between breeds and ages of animals. The pearson correlation coefficients of protein, fat, ash and moisture content of longissimus dorsi chuck of Arsi cattle showed that there was a negative relationship between fat and protein (P < 0.0001) and is in agreement with FAO (1993). This negative relation means that, nine units of the increase in fat percentage are accompanied by a reduction of one unit in protein percentage. Fat and moisture content have significant negative relationship (P = 0.14). The existence of strong negative
relationship between fat and moisture content is also reported by Patten et al. (2008). Protein has no significant relationship with ash and moisture content.

2.1.3.1.2. Effect of muscle location on proximate composition

According to Lawrie (1998), it is feasible that significant differences may exist between specific muscle locations in the carcass or that breed and age has an effect. Amino acid varies between different parts of the carcasses (Lawrie, 1998).

High quality grade (QG 1++) of Hanwoo beef cuts had significantly higher intramuscular fat contents (7.81–24.74%) and significantly lower pH (5.47-5.64), protein (16.94-21.15%), moisture (58.17-70.08%) and ash contents (0.60-0.79%) than low quality grade beef cuts (QG 3) (p<0.05). In each quality grade, the intramuscular fat contents (%) of loin muscles were significantly high whereas those of eye of round muscles 2 were significantly low among 10 cuts (Cho et al, 2008).

Buford et al (2004) showed that muscle pH is variable from one muscle to another. A range in values was observed from a low of 5.6 to a high of 6.30 among different cuts of beef and the differences were found to be significant (P < 0.05). Chavez et al (2012) also reported variations in proximate compositions among various beef muscles where Rhomboideus had the lowest moisture (72.62%) and highest fat content (5.23%).

2.1.3.1.3. Effect of cooking on proximate composition

Cooking can be defined as the heating of meat to a sufficiently high temperature to denature proteins (Davey and Gilbert, 1974). Temperature and cooking time have a large effect on physical properties of meat and eating quality. The components of muscle that control toughness are the myofibrillar proteins and the connective tissue proteins. During heating, the different meat proteins denature and they cause structural changes in the meat, such as the destruction of cell membrane, shrinkage of meat fibers, the aggregation and gel formationof myofibrillar and sarcoplasmic proteins shrinkage and solublisation of the connective tissue (Palka and Daun, 1999., Tornberg, 2005). Smith et al (1987) reported an increase in the total protein content in all cuts of beef.
Cooking of meat is essential to achieve a palatable and safe product (Tornberg, 2005). Brugiapaglia and Destefanis (2012) reported that heat treatments applied to meat in different ways, improve its hygienic quality by inactivation of pathogenic microorganisms and enhance its flavour and tenderness and showed that water had the greatest loss during cooking (retention = 55%) compared to the other nutrients. Protein retention was 98% and fat was the most retained nutrient at > 162%.

Degree of doneness did influence \( P < 0.05 \) the nutrient composition of beef steaks. As the degree of doneness increased, percent fat and protein increased, while percent moisture decreased. Cooking steaks to a higher degree of doneness resulted in a higher caloric value when reported per 100 g basis (Smith et al., 2011).

The most dramatic changes of meat during heating, such as shrinkage, tissue hardening, juice release, and discoloration, are caused by the changes in muscle protein denaturation (Hamm & Deatherage, 1960; Bowton et al, 1976; Bowers et al, 1987). Hamm (1977) summarized that for the beef muscle, the changes of tenderness, rigidity, and water holding capacity of meat caused by heating occur in two phases: the first phase being between 30 and 50 ºC and the second phase between 65 and 90 ºC.

2.1.3.2. Fatty acid profile

Fatty acid composition of an animal is impacted by overall fat and muscle content due to the composition of neutral lipids and phospholipids (Wood et al., 2008). The information about the fatty acid composition of foods is scarce and specially limited to foreign tables (Schaefer, 2002). The fatty acid content of different meats might be influenced by a wide variety of factors, including animal breed, external and internal fat levels, climate, and breeding, feeding and rearing conditions (Bragagnolo, 1997). These factors may vary according to the region where animals are created and according to cultural practices.

According to USDA guidelines (2008), a 100 g serving of beef qualifies as “extra lean” if it has less than 5 g of total fat, 2 g or less of saturated fat, and less than 95 mg of cholesterol. It qualifies as “lean” if it has less than 10 g of total fat, 4.5 g or less of saturated fat, and less than 95 mg of cholesterol. Currently, there are 29 beef cuts that fall into these categories, allowing for lean beef to be included as an integral part of a healthy diet (USDA, 2007). One of the components in lean beef hypothesized to have an anti-
carcinogenic effect, along with positive effects on cardiovascular health, body fat composition, and other potential health benefits, are conjugated linoleic acids (CLA) (Ip et al., 2002; Lee et al., 2005). Such CLA are isomeric forms of linoleic acid (C18:2) with the double bonds separated by a single bond, giving these fatty acids unique physical and chemical properties (Stipanuk, 2000). Such CLA are produced in the rumen, and make beef fat one of the richest natural sources of CLA (Chin et al., 1992; Stipanuk, 2000). Grass-fed cattle tend to have a greater concentration of CLA than grain-finished cattle (French et al., 2000; Leheska et al., 2008). The conventionally fed beef strip loins contained 45.1, 46.2, and 2.77 g/100g of saturated fat (SFA), monounsaturated fat (MUFA), and polyunsaturated fat (PUFA), respectively. The grass fed beef strip loins possessed a greater amount of SFA, but a lower concentration of MUFA, 48.8 and 42.5 g/100g, respectively. The difference in SFA concentration was primarily due to a greater concentration of stearic acid in the grass fed beef (Leheska et al., 2008). Stearic acid has been shown to have no effect on blood cholesterol, unlike other SFA that increase serum cholesterol, such as myristic and palmitic acids (Hegsted et al., 1965; Keys et al., 1965). Monounsaturated fatty acids, such as oleic acid, typically make up half of beef fat (Leheska et al., 2008) and have been shown to exude beneficial health effects on LDL cholesterol levels and other cardiovascular disease (CVD) risk factors (Kris-Etherton et al., 1999).

2.1.3.2.1. Effect of muscle location on fatty acid profile

Beef cuts had higher proportions of SFA and lower proportions of PUFA (principally of the n-3 family) than dark chicken meat and Total saturated fatty acid (SFA) contents were approximely three times higher in biceps femoris than in semimembranosus (Almeida et al, 2006). The fatty acid profile of the beef is mostly diet dependent, while genotype effects for instance on the n_6:n_3 ratio are likely to be minor as can be seen from the study of Rule et al. (2002) where differences between beef cattle and bisons were negligible compared to those between grazing and feedlot fattening. As the beef fattens, the concentrations of saturated fatty acids and monounsaturated fatty acid increase at a greater rate than concentration of polyunsaturated fatty acids (De Smet et al., 2004). Triacylglycerols deposited within the adipocytes as livestockfattens dilutes phospholipids
concentration, thus explaining the decrease in polyunsaturated to saturated fatty acid ratio with increasing fatness (De Smet et al., 2004). The ratio of polyunsaturated to saturated fatty acid ratio increases as the intramuscular fat content decreases (De Smet et al., 2004). Dinh et al. (2009) observed that the proportion of monounsaturated fatty acids was greater ($P \leq 0.005$) than saturated fatty acids regardless of cattle breed and that total fatty acid concentration was positively correlated with intramuscular fat content ($P \leq 0.005$).

Zajac et al. (2007) detected six saturated, six mono- and seven polyunsaturated fatty acids (PUFA) in eight different muscles of Hereford Cross Friesian heifers. The analysis of variance showed significant differences between muscles except of C15:0. The most abundant acids in all analysed samples were oleic (average 36.5%), palmitic (average 22.4%) and stearic (average 14.3%) acids. The amount of saturated acids was the highest in Serratus ventralis and Longissimus dorsi muscles (44.4% and 43.5% respectively) and the lowest in Semi membranosus (36.4%). The percentage of monounsaturated fatty acids was the lowest in Semi membranosus (42.6%) and the highest in Pectoralis profundus (53.4%). Semi membranosus muscle had the highest (21.0%) and Pectoralis profundus the lowest (6.9%) amount of polyunsaturated fatty acids.

2.1.3.2.2. Effect of cooking on fatty acid profile

Literature data for true retention of beef lipids vary remarkably: from 90 to 122% for braising, from 91 to 160% for broiling and from 71 to 125% for roasting (Bragagnolo and Rodriguez-Amaya, 2003). This variability has been attributed to the presence of variable levels of subcutaneous and intermuscular fat, whose rendering and subsequent infiltration into the lean tissue during cooking lead to True retention of nutrient values higher than 100%.

It is well known that meat composition, especially its fat content, combined with a specific cooking methodology are among the factors that mostly affect the final quality of meat products (Serrano et al. 2007).

Several authors had pointed out that the cooking process can affect the lipid composition of meat, especially the fatty acid content, by changing the nutritional value of cooked products in relation to raw samples. Several mechanisms that occur during
cooking, such as water loss and lipid oxidation, diffusion and exchange, can lead to relative changes in some FA (Dal Bosco et al, 2001).

Rodriguez-Estrada et al. (1997) reported that heat treatment can lead to undesirable changes, such as loss of essential fatty acids (FA), reducing the nutritional value of meat, mainly due to lipid oxidation. It has been shown that a higher unsaturation index in meat may affect its oxidative stability, since the unsaturated FA are more prone to oxidation (Bou et al. 2001). However, there is a great variability in changes concerning individual FA in response to different cooking methods (Badiani et al, 2002; Harris, et al, 1992). Compared with the raw meat control, cooking led to a significant loss of moisture and, consequently, to a significantly higher intramuscular fat content, with significant differences (P<0.05) among treatments (microwaving > boiling = grilling)( Alfaia et al, 2010). All the cooking methods had a moderate impact on the fatty acid profile of beef, with the content of 16 of the 34 FA analyzed affected (P< 0.05) by the thermal treatments. In addition, no novel fatty acid residues or other artefacts due to cooking were detected. Some SFA, namely 14:0, 16:0, 17:0 and 18:0, as well as MUFA, 18:1c9, were significantly higher (P<0.05) in cooked meat samples than in the uncooked meat control. In contrast, the percentages of 18:2n6 and almost all long chain n6 FA decreased significantly (P<0.05) in cooked beef compared to raw meat (Alfaia et al, 2010). Total CLA content (mg/g muscle) was significantly higher (P<0.001) in cooked beef than in raw cuts as a result of moisture loss. In fact, the mean values of total CLA in raw beef mounted to 0.05 mg/g muscle. This value was increased after cooking up to 0.08 mg/g for grilling or 0.09 mg/g for boiling and microwave heating (Alfaia et al. 2010).

2.1.3.3. Cholesterol

Cholesterol content in meat has led some consumers to perceive red meat and specifically beef in a negative image. Within the human diet an elevated intake of saturated fatty acids can lead to an increased concentrationof low-density lipoprotein cholesterol resulting in an increased risk for coronary heart disease. In contrast, the consumption of polyunsaturated fatty acids decreases the amount of low-density lipoproteins (Bohac and Rhee, 1988). Cholesterol has a primary role in stabilizing the membrane of cells and
affects the fluid characteristics of the cell membrane as well as being a component of meat lipids (Du and McCormick, 2009). Cholesterol within the membrane is associated with phosphatidyle choline which is a major phospholipid within the cell membrane. This indicates an increase in cholesterol is correlated with an increase in polyunsaturated fatty acids as phospholipids are rich in polyunsaturated fatty acids (Rule et al., 1997). Stabilization of the cell membrane occurs when a hydroxyl group of cholesterol forms a hydrogen bond with the nearest phospholipid helping to immobilize the outer outside surface of the membrane (Berg et al., 2007). Rule et al. (1997) also stated that altering the concentration of cholesterol within muscle may redistribute the phospholipids in the cell and change the unsaturation of the membrane fatty acids. Genetic changes could lead to these differences in cholesterol concentration.

Taylor et al., (1990) reported that there was no difference (P< 0.05) in the cholesterol content of muscles between the two breeds when weight, fat thickness, and feeding history were equivalent. Taylor et al., (1990) also reported that feed type and carcass fatness are not good indicators of cholesterol content. These results are in agreement with Wheeler et al. (1987) who reported that breed type had no effect on cholesterol concentration. Taylor et al. (1990) reported a correlation between intramuscular fat and cholesterol content within the Brahman group when intramuscular fat was greater than 3.6%, and concluded that as intramuscular fat content increased so did cholesterol content if the fat percentage was large. Almeida et al (2006) depicted the cholesterol content in raw beef semimembranosus and biceps femoris muscle as 51.97 ± 1.40 and 63.02 ± 3.62 respectively.

Cooked Longissimus muscle contained 26.8% higher cholesterol (wet weight basis) than the uncooked muscle of beef cattle and this is the result of an increase in concentration due to loss of moisture and some fat during cooking, not an actual increase in cholesterol content (Wheeler et al., 1987). However, according to Lewis et al. (1993) cholesterol values in meat do not change appreciably on cooking, since negligible amounts are lost from membranes.
According to van Heerden (2007), the cholesterol content for three cooked lamb cuts was higher, although not significantly, than the raw cuts, with the shoulder cut containing the highest cholesterol.

2.1.4. Mineral content in beef

Mineral content of fresh meat is roughly 1% and can be divided into macrominerals and microminerals (trace minerals). Humans cannot synthesize minerals and must consume minerals within their daily diet. Those minerals required for biological functions are considered essential nutrients including being a cofactor of enzyme systems (Kinsman et al., 1994), while other minerals are considered non-essential. Meat is a good source of all minerals with the exception of calcium (Hui et al., 2001). Kinsman et al. (1994) stated that the biologically important minerals for human nutrition are present in sufficient amounts in the flesh of animals due to muscles possessing similar mineral-dependent biological systems.

The mineral of greatest importance within muscle food is iron, with its bioavailability being an important factor of meat (Hui et al., 2001). Dietary iron is classified as either heme or non heme iron with heme iron being essential in transporting of oxygen within the blood and is attached to both myoglobin and hemoglobin molecules. Meats with a large concentration of these pigments are a good source of iron (Kinsman et al., 1994). A portion of the iron located in meats is heme iron which is present in animal tissue, but heme iron is not available in any plant tissue (Hui et al., 2001; Kinsman et al., 1994). Heme iron absorption is much greater than non heme and its absorption is not affected by other dietary factors (Hui et al., 2001). Two factors can have an impact on the concentration of iron in meat, muscle type (Type I muscle fibers have a greater concentration of iron compared to Type IIB) and age of the animal at harvest (as animals age, the iron content will increase). The mineral potassium is important for electrical and cellular functions within animals (including humans; Mateescu et al., 2012). Three trials conducted by Clark et al. (1972) evaluated the potassium distribution within beef carcasses dependent on different slaughter weights. It was reported within the trial
Review of Literature

comparing Hereford steers that lighter weight cattle had a greater percentage (23.7% vs. 20.8% vs. 19.3%) of potassium than intermediate and heavier cattle.

Mineral content varies more due to muscle effects than breed and sex differences (Doornebal and Murray, 1981). Mateescu et al. (2012).

Various factors, such as the concentration of minerals in the diet of the animal, hormones, age, gender and region, may cause variations in the mineral composition of the meat (Doyle 1980).

Huerta-Leidenz et al (2003) reported the following quantity (mg/100g) of minerals in longissimus dorsi muscle of Venezuelan tropical cattle: Ca (2.77 +/- 1.57), Mg (21.62 +/- 3.11), P (211.4 +/- 35.88), Na (76.06 +/- 30.88), K (243.81 +/- 63.93), Fe (1.93 +/- 0.58), Zn (4.13 +/- 0.82), Cu (0.084 +/- 0.041) and Mn (0.026 +/- 0.016). García-Vaquero et al. (2011) demonstrated that in cattle, non-essential and essential trace element concentrations significantly varied between muscles. The most active and less fat content muscles showed in general the highest essential and the lowest non-essential trace element accumulation in comparison with the other muscles analyzed.

Maria et al (2008) investigated the vitamin and mineral content in beef, and reported the following quantity of minerals in beef hydrolysates: Fe: 1.53 ± 0.28, P: 124 ± 1.27 and Calcium: 8.20 ± 2.12.

The average P, K, Na, Mg, Ca, Zn, Fe, Mn concentration in beef muscle was found to be 240.30 ± 3.43, 515.03 ± 15.3, 180.06 ± 2.89, 48.54 ± 1.02, 46.50 ± 1.64, 0.975 ± 0.009, 0.947 ± 0.001 and 0.175 ± 0.184 respectively (Serap et al. 2010). Zarkadas et al. (1987) reported in bovine muscles a higher concentration of potassium, sodium, phosphorus and chlorine and a lower concentration of calcium, magnesium, zinc and iron.

Huerta-Montauti et al. (2007) investigated the various domestic beef cuts for restaurant use in Venezuela and reported that the Biceps femoris contained Ca, Fe, Mg, P, K, Na, Zn and Cu as 6.77 ± 0.18, 2.39 ± 0.03, 23.35 ± 0.22, 196.99 ± 1.00, 347.01 ± 2.02, 61.25 ± 0.71, 3.78 ± 0.06 and 0.025 ± 0.001 respectively, whereas, the same values for
longissimus dorsi thoracis were 7.41 ± 0.21, 1.92 ± 0.04, 23.36 ± 0.26, 198.08 ± 1.14, 354.26 ± 2.33, 59.40 ± 0.81, 3.51 ± 0.06 and 0.018 ± 0.001 respectively.

2.1.5. MEAT QUALITY

Galli et al (2008) reported the mean pH in cull cows and early weaned cattles ranging from 5.51 to 5.56. Von Seggern et al (2005) studied the beef chuck and round muscles and recorded that the overall mean and standard deviation for pH was 5.78 ± 0.32. Variations in pH has been shown between muscles as well as within a particular muscles by Gariepy et al (1990). Callow (1939) suggested that proximity to bone might be one reason for variation in muscle pH. Delgado et al.(2005) showed that the Mean values of pH of longissimus dorsi muscle varied from 5.71-5.73 in retail beef in Mexico. Hildrum et al. (2009) reported that the difference in ultimate pH between muscles was highly significant in case of Norwegian Red bulls. Dunne et al. (2008) reported that there was a muscle x time interaction (P<0.001) for muscle pH. The pH of M. Extensor capri radialis (ECR) was higher (P<0.05) than that of M. Longissimus dorsi (LD) but the magnitude of the difference decreases as time post mortem increased. ECR muscle had higher cook loss than LD muscle.

Much of the water inside meat muscle is held within the myofibril by capillary forces arising from the arrangement of the thick and thin filaments within the myofibril (Huff-Lonergan and Lonergan, 2005). The ability of fresh meat in the form of post-mortem muscles to retain inherent water is defined as water-holding capacity (WHC) which is considered one of the most important quality characteristics of raw products. The quality of fresh meat depends to a large extent on water holding capacity (WHC) which is technologically and economically important not only for food-processing industry but also for consumers as an important attribute during purchasing meat (Prevolnik, et al, 2010). From economic point of view, high WHC is extremely desirable because meat is sold by weight and any water loss leads to a reduction in yield due to loss in the total weight of the meat (Hoving-Bolink et al., 2005; Micklander et al., 2005). The WHC has a great influence on the appearance of fresh meat during retail and might affect the sensory properties of cooked meat (Pedersen et al., 2003). In the retail store, moisture
loss due to poor WHC results in the drip remaining in the package and appeared as red liquid in the bottom of the package which gives the meat an unattractive appearance, leading to loss of sales (Otto et al, 2004). Furthermore, moisture loss incurs during the cooking and processing of meat (Forrest et al., 2000). A number of intrinsic and extrinsic factors affect the development of WHC of meat and the water content of the end products. These factors include genotype, feeding regimes, early post-mortem handling, rate of pH decline, pre-rigor temperature, pre-slaughtering treatments (e.g. fasting, epinephrine injection, and stunning), physical disruption of the product, aging, storage conditions and processing factors. It was proved that early post-mortem events including rate and extent of pH decline, proteolysis and even protein oxidation are all influence the ability of meat to retain moisture (Huff-Lonergan and Lonergan, 2005).

Water holding capacity was higher for Longissimus (LT) than the Infraspinatus (IS) muscles from five contrasting groups of pasture-finished cattle as found by Purchas and Zou (2008).

Stanicic et al (2012) reported the WHC in fresh longissimus dorsi and gluteus medius muscle in beef as 11.78 ± 0.78 and 12.18 ± 0.95 respectively.

Approximately 40% of bovine live body weight is skeletal muscle of which 75% is muscle fibers. Walls (1960) reported that there is considerable variation in fiber diameter, with a range of 10 to 100µm commonly being accepted. The fibers of one muscle may be generally thicker than those of another muscle in the same animal (Hammond and Appleton, 1932). In addition, the fiber diameters vary considerably within the same muscle. Other factors such as species, size, age, breed, sex, and level of nutrition also have been found to influence this variation. A review of early studies caused Joubert (1956) to conclude that males generally have thicker fibers than females. However, when size was considered, he found that there was a slight tendency for females to have thicker fibers than males.

Carcass position has a definite effect on sarcomere length and fiber diameter (Herring et al., 1965). When the carcass is suspended vertically, certain muscles are in a
stretched state, as indicated by sarcomere length, while some are in a shortened state. Muscle fiber characteristics are influenced by many parameters, e.g. genotype, sex, age, feed and management (Ozawa et al., 2000; Vestergaard et al., 2000; Kirchofer et al., 2002).

Rhee et al. (2004) found that cooking loss of the steaks differed ($P < 0.05$) among muscles. Cooking loss was lowest ($P < 0.05$) for Biceps femoris (18.7%) and was followed by Longissimus thoracis et lumborum and Infraspinatus (20.7%); it was highest ($P < 0.05$) for Semitendinosus (27.4%) in steer carcasses.

McKeith et al (1985) recorded that the mean sarcomere length of beef longissimus muscle varied from 1.57 to 1.72.

Cooking caused a rise in pH presumably due to the denaturation of proteins (Dzudie et al., 2000). Heat treatment conditions (internal temperature) have significant effect on the profile of meat texture parameters, such as cohesiveness, elasticity, chewiness and hardness (Bertram et al. 2004). During heat treatment, meat loses 20-40% of its total initial weight due to fluid leakage with the increasing temperature (Zheng et al.2007). Cooking loss is strongly associated with fibres shrinkage and thereby impacts the overall process efficiency and general consumer acceptance of the product. Extent of shrinkage is important for the consumers, because when treating meat with different thermal processes, that cause undesirable changes in meat structure, they can perceive increased shrinkage as an indication of low quality (Barbera and Tassone, 2006).

2.1.6. HEAVY METAL RESIDUE IN BEEF.

Pollution of heavy metals is a global threat to the environment as they are widely present in the earth’s crust, in air, water and food (Matthew et al., 2002). Heavy Metals are those elements which have density more than 5 g/cm³, atomic weight 63.546 to 200.590 (Kennish, 1992) and a specific gravity greater than 4.0 (Connell and Miller, 1984). Although heavy metals by and large remain in ground water and soil yet they tend to accumulate and are very toxic at certain levels. Living organisms normally require some of these heavy metals up to certain limits and in case excess accumulation occurs it will
lead to severe detrimental effects (Kennish, 1992). Once heavy metals are on the rampage to the environment, they remain for years to increase the chances of revelation to humans and livestock. The increase in heavy metal pollution in the ecosystem is because of various human and natural activities (Srikanth et al., 2004). Recent studies have shown that the modern products like cosmetics (Aslam et al., 1979., Hardy et al., 1998), mercury amalgam dental filling (Ellender et al., 1978; Chin et al., 2008) and ground water residues (Sanyal and Nasar, 2002; Ghosh et al., 2004) of certain chemicals lead to chronic exposure to these heavy metals. Foodstuffs grown on contaminated soil or irrigated with impure water accumulate metal contents and are a big source of heavy metals exposure to the animals and humans (Ward and Savage, 1994).

Animals reared on contaminated fodder become continuous source of heavy metal residues in edible tissues and milk. Heavy metal contamination in meat and other edible tissues is a matter of great concern for food safety and human health. These metals are toxic in nature and even at relatively low concentrations can cause adverse effects (Mahaffey, 1977; Santhi et al., 2008). Different researchers have reported the instances of contamination of heavy metals in meat products during processing (Brito et al., 2005; Santhi et al., 2008). While the feeding of cattle on the contaminated feed and rearing of livestock in proximity to polluted surroundings were found to be responsible for heavy metal pollution in meat (Korenekova et al., 2002; Sabir et al., 2003; Miranda et al., 2005).

The presence of heavy metals in pesticides is one of the main sources of heavy metal pollution in vegetables (Beavington, 1975; Chiroma et al., 2007). Excessive exposure of elements such as cadmium, lead, arsenic, chromium and mercury is toxic for plants, animals and human beings (Llobet et al., 2003). These metals have direct effect on animal health and indirect effect on human health (Hooda et al., 1997). Heavy metal pollution in rural areas is due to disposal of industrial effluents and sewage sludge which causes problem for grazing animals because they depose heavy metals on pastures grasses or forages (Smith et al., 1991). The polluted meat from edible animal species
exposed to heavy metals in the environment is sold in the market for human consumption (Iwegbue, 2008).

The reported values of Cadmium, Chromium, Lead and Arsenic in meat of cattle are given below:

<table>
<thead>
<tr>
<th>Heavy Metals</th>
<th>Levels (mg/kg)</th>
<th>Reference</th>
</tr>
</thead>
<tbody>
<tr>
<td>Cadmium (Cd)</td>
<td>0.0228</td>
<td>Licata et al, (2004)</td>
</tr>
<tr>
<td></td>
<td>225-890</td>
<td>USAF, (1990)</td>
</tr>
<tr>
<td></td>
<td>1.0</td>
<td>Korsrud et al, (1985)</td>
</tr>
<tr>
<td></td>
<td>0.00339-0.131</td>
<td>Miranda et al, (2005)</td>
</tr>
<tr>
<td></td>
<td>0.00022-0.0137</td>
<td>Rahimi and Rokni (2007)</td>
</tr>
<tr>
<td></td>
<td>0.0077 and 0.0833</td>
<td>Alonso et al (2000)</td>
</tr>
<tr>
<td></td>
<td>80-200</td>
<td>Shore and Douben (1994)</td>
</tr>
<tr>
<td>Chromium (Cr)</td>
<td>16.45 - 8.8</td>
<td>Demirezen and Uruc (2006)</td>
</tr>
<tr>
<td>Lead (Pb)</td>
<td>0.198-0.790</td>
<td>Abou Doina (2008)</td>
</tr>
<tr>
<td></td>
<td>0.033 and 0.0475</td>
<td>Alonso et al (2000)</td>
</tr>
<tr>
<td>Arsenic (As)</td>
<td>0.0108 and 0.0102</td>
<td>Alonso et al (2000)</td>
</tr>
<tr>
<td></td>
<td>14</td>
<td>Humphreys (1990)</td>
</tr>
</tbody>
</table>

Cadmium is the most abundant, naturally occurring element and was discovered in early 19th century (Bernard, 2008). Cadmium is widely distributed in air, soil, water, plants and finally in animal tissues (Friberg et al., 1979; Hovmand et al., 1983). Once cadmium is absorbed, it accumulates in the body even throughout the life (Bernard, 2008). Even low concentration of cadmium can adversely affect the number of metabolic processes in animal body (Bernard, 2004; Nordberg et al., 2007). Cadmium intoxication can lead to kidney, bone and pulmonary damages (Godt et al., 2006). Data indicated that cadmium toxicity affects various organs such as the liver, lung, testis and hematopoietic system in animals (Kocak and Akc, 2006). Studies on cadmium toxicity in animals as well as in
humans are well documented (Satoh et al., 2002; Thompson and Bannigan, 2008). Krajnc et al., (1983) found that contamination in animals occurs through forage, feed and water while in human being cadmium contamination can occur by the utilization of dairy products like meat and milk. Khalafalla et al (2011) reported 1.40 µg/kg Cd in beef muscle in Egypt.

Chromium is the 21st most abundant mineral in earth crust and found in combination with iron and oxygen in the form of chromite ore. Its harmful effects on humans, animals and plant health are partially related to the valence state, as chromium (VI) is most toxic and carcinogenic than others (Jadhav and Turel, 1994). Khalafalla et al (2011) recorded 11.20 µg/kg Cr in beef muscle in Egypt.

All the food of animal origin contains lead in higher concentration (Smirjdkova et al., 2005). Cattle are mostly at risk of lead poisoning due to the natural curiosity, licking habits, and lack of oral discrimination and these make any available lead-containing materials, as discarded batteries, farm machinery grease or oil and caulks or putties, potential sources of poisoning. Lead and other heavy materials tend to lodge in the reticulum of ruminant animals. This provides a reservoir from which lead can continue to be absorbed into the bodies of these animals (Radostitis al., 2007).

So, the contamination of the human consumer can happen by using meat, offal and milk (Enriquez-Dominguez et al., 1998). Pb accumulates in the tissues/organs of cattle but their concentrations were higher in liver and kidneys than the other organs and tissues (Szkoda and Zmudzki, 2005). Similarly, Marinda et al. (2005) conducted the same study on cattle of industrial and rural area of Asturias (northern Spain) to determine the lead concentration. Their observations indicated that samples collected from cattle of industrial area have high concentration of lead especially in liver and kidneys than that of rural area.

Arsenic is among the most toxic metals found in the environment. Inorganic arsenic is generally more toxic than organic form. has been found that arsenic can accumulate in cattle tissues and organs through drinking of water contaminated with arsenic (Delowar et al., 2005). High concentration of arsenic was found in west Bengal in
shallow tube well water i.e. 0.171 ppm to 0.497 ppm, 9.671 ppm to 14.964 ppm in soil and in paddy plants from 0.994 ppm to 3.059 ppm and it is transferred to cattle by the use of contaminated paddy plants as fodder which accumulates in milk upto 0.156 ppm. This concentration was 12 times higher than the healthy cow milk (Rana, 2008).

Al-naemi (2011) reported mean concentrations of lead in muscles, livers and kidneys of slaughtered cattle as 0.071, 0.472 and 0.398 mg/kg, respectively and for cadmium results showed that muscle, liver and kidney samples of slaughtered cattle were contained mean values of 0.009, 0.0591 and 0.0979 mg/kg, respectively.

2.1.7. PESTICIDE RESIDUES

Pesticides have been used in public health sector for disease vector control and in agriculture to control and eradicate crop pests for the past several decades (Clark et al, 1997). There had been a rapid rise in the quantity of pesticides used in agriculture over the past few years (Hodgson, 2003). Organochlorine pesticides such as dichlorodiphenyl trichloroethane (DDT), lindane, endosulfan, hexachlorocyclohexane (HCH) etc are employed to control ectoparasites of farm animals and pets (Ntow et al, 2006). Most of the pesticides, especially the organochlorines are very resistant to microbial degradation and therefore can accumulate in human body fats and the environment posing problems to human health (Ejobi et al, 1996). Meat may contain high levels of pesticide residues as a result of concentration of the residues in the tissues following cattle dipping or vector control or when they feed on feedstuffs contaminated with these chemicals (Jayashree and Vasudevan, 2007). Meat samples collected from different parts of India were reported to contain DDT and HCH residues (Kalra et al, 1979., Mehrotra, 1985). Darko and Acquaah (2007) examined beef samples collected from different abattoirs in Ghana and found (µg/kg) DDT, Lindane, Aldrin, Endosulfan and Dieldrin as  18.83, 2.07, 1.43, 1.88 and 5.92 respectively in beef from Kumasi abattoir and 10.82, 0.60, 0.73, 0.59 and 11.48 respectively in beef from Buoho abattoir. WHO has recommended a maximum residue limit of 6.0 µg/kg for lindane, 844.28 µg/kg for DDT and 6.0 µg/kg for dieldrin in foodstuffs. Sengupta et al (2009) analysed meat samples randomly collected from
different areas of West Bengal, India and found contamination with traces of organochlorine pesticides (0.01-0.22 µ g/g) and organophosphorus pesticides (0.111-0.098 µ g/g). The overall contamination was found to be highest in cattle which might be due to the fact that cattle are the largest feeders among the studied animals (cattle, goat and chicken) and that the leftover portion of the vegetables, used as one of the key ingredients in cattle feed preparation, where residues of the pesticides are frequently encountered. In that study, malathion was detected at the highest concentration followed by DDT, dimethoate, HCH and endosulfan. In chicken, initial concentration of pesticides was low and became negligible after baking and cooking. So, roast (baked) and cooked chicken is safest as a food substrate among the three animals in terms of health risk and cooking is more effective than baking in terms of reducing the pesticide load for any raw meat samples. Vijayan et al (2006) also recorded organo chlorine pesticide residues in meat samples slaughtered in Kerala. Noha et al (2010) studied 160 beef and mutton samples in Menofia Governate and found organo chlorine residues including total DDT, (HCH) α-hexachlorocyclohexan, Hexachlorobenzene (HCB), aldrin, dieldrin, endrin in beef meat as 12.5%, 10%, 10%, 10%, 10% 12.5% respectively. While the residue levels were detected in Mutton meat with an incidence of 25%, and 12.5% respectively. The Most detectable chlorinated hydrocarbon residues were total DDT in Both Meat samples either beef or mutton. Muthukumar et al (2010) reported that cooking of endosulfan (Endoin 35 EC) spiked meat resulted in 58.33–64.59% reduction in α-endosulfan and 55.93–61.60% reduction in β-endosulfan. Among the cooking methods, pressure cooking was most effective in reducing both α- and β-endosulfan.

2.2. POULTRY

A complete and balanced diet is necessary for human health and vitality. Protein is an essential element to form a perfect diet. Protein is usually produced by two kinds of resources that are plants and animals. Due to rapid growth of human increasing day by day, protein short fall seems more serious and painful in poor developing countries as compared to the developed countries. People of developed countries take 80-96 g protein daily. (Anonymous, 1998) The poultry meat is a good source of protein and its high meat yield, lowshrinkage during cooking, ease of cooking and serving and low cost, chicken
appears more frequently than any other animal as a source of meat in the diet of people throughout the world and broilers dominated the world poultry consumption picture, contributing about 70% to the world poultry market (Roenigk 1999). Chicken meat production in the world was 74.006 million tonnes in 2010. The largest producers of chicken meat are the United States (16.348 million tonnes) followed by China (12.500 million tonnes) and Brazil (11.420 million tonnes) (Kokoszynski et al, 2013).

India is the fifth largest producer of eggs and ninth largest producer of poultry meat in the world, producing over 34 billion eggs and about 600,000 tons of poultry meat in 2004. In the overall market for poultry products, India was positioned 17th in World Poultry Production. The poultry sector in India has been growing at a much faster rate, along with other industries such as BPO and Securities market. Over the past decade the poultry industry in India has contributed approximately US $229million, to the Gross National Product (GNP). The average per capita poultry meat consumption is also estimated to increase from 0.69 to 1.28 kilograms, during the 2000-2004. Overall, analysts studies that the total egg consumption is estimated to increase from 34 billion in 2000 and to 106 billion in 2020, while poultry meat consumption is predicted to increase from 687 million kilograms to 1,674 million kilograms (Anonymous, 2005). Total meat production from cattle, buffalo, sheep, goat, pig and poultry at the all India level increased from 4.01 million tonnes in 2007-08 to 5.5 million tonnes in 2011-12. Poultry meat production from commercial poultry farms were included in the production estimates of meat from 2007-08 onwards. Growth in meat production achieved in 2011-12 was about 13.25% over previous year. (State of Indian Agriculture, 2012-13, Government of India, Ministry of Agriculture, Department of Agriculture and Cooperation, Directorate of Economics and Statistics, New Delhi, Page 153).

In addition to high content of meat (especially breast muscles) and low content of skin with subcutaneous fat and abdominal fat in carcass, modern consumers are also paying more attention to the quality of meat as a result of the increased incidence of lifestyle-related diseases such as obesity, diabetes, heart attacks and atherosclerotic strokes. Apart from good meatiness and low fatness of broiler carcasses, more importance is now given to the chemical composition, fatty acid profile, cholesterol content,
2.2.1. CARCASS CHARACTERISTICS OF BROILER:

White meat such as chicken meat according to Jaturasitha et al. (2008) is superior to red meat in health aspects because of its comparatively low content of fat, cholesterol, and more importantly for men, Iron. Chicken meat is unique in that its price is comparatively low, easy to partition into smaller parts and no religious restriction against its consumption (Jaturasitha, 2004). The primary goal of broiler breeding is to improve profitability of broiler meat production. Until recently most birds were sold whole, but there has been a dramatic increase in the proportion of birds being grown for portioning and further processing (Ewart, 1993). There are several factors affecting the productive and carcass performance of broiler chickens, and these include breed or strain, sex, nutrition, housing and stocking rate. The success of poultry meat has been strongly related to improvements in growth and carcass yield, mainly by increasing breast proportion and reducing abdominal fat. Chen et al (2013) showed that outdoor access had no effect on growth performance, carcass yield, meat yield, muscle protein content, muscle fiber characteristics, or water-holding capacity (P > 0.05). Chickens from the outdoor access groups had a better appearance and degree of evenness. Intensive selection of meat type chicken growth for more than 50 years has increased growth rate, but rapid growth has been accompanied by a number of negative consequences, including an increase in fat deposition (Griffin, 1996). Abdominal and subcutaneous fat deposition in chickens selected for rapid growth is associated with changing concentrations of hormones and neural control mechanisms (hunger-satiety control mechanisms) that regulate feed intake. Therefore most modern meat type chickens eat more than they require their muscle growth and maintenance (Smith & Pesti, 1998). This excessive energy intake leads to increasing fat deposition in the body. In chicken fat accumulates in great quantity in thigh followed by breast.

Chukwuka et al (2010) evaluated 162 broiler birds of three different strains (Ross, Abor acres and Anak) maintained in uniform diet and found: Dressing percentage: 66.63 -69.75%, Head (%): 1.96-2.3%, Neck (%): 3.8-4.49%, Shank (%): 3.2-3.39%, Heart (%):
0.53-0.59%, Drumstick (%): 9.63-9.90%, Wing (%): 7.9-8.1%, Bone (%): 21.67-24.13%, Gizzard (%): 5.6-8.6% and cooking loss (%): 9.25-10.56%.

Kokoszynski et al (2013) studied the carcass characteristics of different broiler birds and found: carcass dressing %: 72.2-72.9%, neck (%): 3.3-3.4%, wing (%): 10.1-10.8%, breast muscle (%): 28.9-29.3%, leg muscle (%): 21.8-22%, skin with fat (%): 8.8-10.5% and abdominal fat (%): 1.6-1.9%.

Literature is replete with information regarding breed effect on carcass characteristics. It was reported that breed significantly affected live weight (Shalin and Elazeem, 2005; Musa et al., 2006; Jaturasitha et al., 2008), carcass weight (Ojedapo et al., 2008; Olawumi and Fagbuarom, 2011), breast and leg muscle weight (Musa et al., 2006), fat and edible giblets weight (Musa et al., 2006; Ojedapo et al., 2008) and back and drumstick weights (Ojedapo et al., 2008) of broiler chickens. Some previous studies also observed significant sex effect on live weight (Shahin and Elazeem, 2005) and carcass traits (Merkley et al., 1980; Wiseman and Lewis, 1998; Shahin and Elazeem, 2005; Ojedapo et al., 2008) of broiler chicken breeds. Globally, few fast-growing broiler strains, provided by commercial breeding companies, are used to produce chicken meat in intensive fattening systems. Less-intensive fattening is expected to result in leaner carcasses (Khantaprab et al., 1997) and, consequently, in a higher proportion of retail cuts.

However, genotype (breed and strain) also plays a major role in carcass fatness (Jaturasitha et al., 2004a; Shahin and Elazeem, 2005). These 2 factors have also repeatedly been shown to influence meat quality, too. Some of the meat quality traits are especially affected by muscle fiber types and sizes (Klont et al., 1998), properties strongly determined by genotype. Concerning the fatty acid profile of the muscle lipids, the effect of genotype is low compared with that of feeding, but a different growth intensity resulting from genotype might still affect fatty acids relevant to human health.

**2.2.3. NUTRITIONAL PROFILE OF BROILER MEAT:**

Nutrient composition studies are strongly affected by the animal itself. The sex, age, health status, time of sampling, feeding regime and genotype of the chicken influence the
composition of the meat. Poultry, in particular, are able to maintain their intestinal physiology resulting in a good preservation of the dietary polyunsaturated fatty acids which is not the case for other meats. These fatty acids have been shown to be easily absorbed into the tissue of the birds, making chicken meat a target for modified omega-3 meats for example. This uptake of fatty acids, however, appears to be influenced by the ability of the individual genotypes to increase their adipose tissue (Bourre, 2005).

Fast-growing broiler chickens are usually slaughtered at 6 weeks of age, which is associated with the attainment of optimum body weight, high dressing percentage, high content of breast muscles, high feed conversion and feather maturity. In addition to high content of meat (especially breast muscles) and low content of skin with subcutaneous fat and abdominal fat in carcass, modern consumers are also paying more attention to the quality of meat as a result of the increased incidence of lifestyle-related diseases such as obesity, diabetes, heart attacks and atherosclerotic strokes. Apart from good meatiness and low fatness of broiler carcasses, more importance is now given to the chemical composition, fatty acid profile, cholesterol content, microstructure, and physicochemical and sensory properties of meat (Grabowski and Kijowski, 2004).

Broiler meat production has been greater than beef and pork since 1996 and is projected to have the highest rate of growth recorded in billions of pound until at least 2018 because broilers are the highest, most efficient feed convertor (USDA ERS, 2007). Chicken meat has been promoted as a lean protein source as most of the fat is stored as subcutaneous fat and within the skin membrane making it easy to remove prior to cooking (Decker and Canton, 1992; Wang et al., 2010). In developing countries, poultry meat is an important staple as chickens grow quickly and have high feed efficiencies. Poultry meat provides energy and balanced protein in regions of the world where populations typically have these deficiencies (Farrell, 2009). In addition, since chickens have monogastric digestive systems, altering the lipid composition in meat can be as simple as supplementing their diet (Decker and Canton, 1992). Chicken meat is relatively low in cholesterol (64mg/100g of meat), only 30% of the lipids are saturated, and the largest percent of lipids is stearic acid which has no effect on blood cholesterol levels. Altering fatty acid composition of chicken through feed supplementation during
production would provide for a more optimal nutrient dense protein source (Decker and Canton, 1992).

The typical make-up of chicken breast meat with skin is 69.5% water, 20.9% protein, and 9.25% lipids with 28.7% of the lipids being saturated, 41.3% monounsaturated (MUFA), and 21.2% polyunsaturated (PUFA). There are approximately 64g of cholesterol/100g breast meat and skin along with a good source of micronutrients such as calcium, iron, magnesium, potassium, and zinc (USDAARS, 2012). When skin is removed from breast meat, protein remains similar at 21.0%, moisture content increases to 75.8%, and lipid content decreases by 71% to a lipid content of 2.6% with saturated, MUFA, and PUFA content each decreasing by about 6%. The composition of dark meat (thigh meat with skin) averages 16.2% protein, 66.6% moisture, and 16.6% lipids. The content of saturated, MUFA, and PUFA long chain fatty acids are similar to white meat with skin (USDAARS, 2012).

The pH of meat has a great impact on three sensory quality characteristics of muscle foods: appearance/color, texture/tenderness, and flavor, all of which affect the consumer acceptance of meat (Offer et al, 1983), (Min et al 2005).

The chemical variables of muscles in meat hybrid broiler chickens were investigated by Suchý et al. (2002) who found that breast muscles contain higher contents of protein, ash and phosphorus and lower contents of dry matter, fat and calcium whereas thigh muscles have higher contents of dry matter, fat and calcium, and less protein, ash and phosphorus.

The most important components of poultry meat are potassium (0.4%), phosphorus (0.2%), sodium (0.09%) etc. (Lazar, 1990). The main quality features of poultry meat are chemical composition and the ratio of muscles to fat in carcass. The chemical composition of poultry meat differs significantly, the differences in chemical composition were found between white and red muscle tissues (Matušovičová, 1986). Steinhäuser et al. (2000) claimed that proteins are the most important components of meat from nutritional and technological aspects. The content of proteins in muscles is reported to range between 18 and 22%. Proteins are the major component of dry matter of
meat, the protein content in muscles is variable and depends on the function of a particular tissue (Ingr, 1996). According to Simeonovová (1999) breast muscles contain approximately 22% proteins, while in thigh muscles, which contain more fat, approximately 17.20% of proteins was found.

### 2.2.3.1. Proximate composition

Meat is the muscles of animals, including the organ and glands. Meat also includes the flesh of poultry and fish (Bown, 2008). In general, meat contains 60-80% of water, 15-25% of protein and other components. Meat also contains high cholesterol, fat and SFA and less unsaturated fatty acid (Bragagnolo, 2001). Broiler carcass contains high fat, less protein and higher cholesterol (Mendes et al., 1994). The meat and egg of indigenous chickens are widely preferred by consumers because of their lean meat (less fat and cholesterol), more protein content, taste, pigmentation and suitability for special dishes which even if they fetch premium prices compared to the products from exotic chickens (Horst, 1991; Islam and Nishibori, 2009).

Meat from poultry contains several important classes of nutrients and it is low in calories. The fat contains essential fatty acids; the proteins are good sources of essential amino acids (Mountney and Parkhurst, 1995; Van Heerden et al., 2002; Wattanachant et al., 2004a) and also excellent sources of water-soluble vitamins and minerals, such as iron and zinc (Van Heerdin et al., 2002; Boccia et al., 2005). Chicken contains about 16.44 - 23.31% protein, 0.37 - 7.20% fat, 0.19 - 6.52% ash, and 72.8 - 80.82% moisture content (Smith et al., 1993; Xiong et al., 1999; Abeni and Bergoglio, 2001; Al-Najdawi and Abdullah, 2002; Van Heerden et al., 2002; Wattanachant et al., 2004; Chuaynukool et al., 2007). The chemical composition of poultry meat has been shown to be related to species, breed, muscle type, sex, age, and method of processing of carcasses (Ngoka et al., 1982; Smith et al., 1993; Ding et al., 1999; Abeni and Bergoglio, 2001; Al-Najdawi and Abdullah, 2002; Van Heerden et al., 2002; Wattanachant et al., 2004; Boccia et al., 2005; Chuaynukool et al., 2007; Wattanachant and Wattanachant, 2007). Ding et al. (1999) showed significant differences in fat contents between broiler and local chickens. Souza et al (2011) studied the physic-chemical and proximate composition of two strains
of broiler and found pH: 5.7 to 5.8, moisture: 75.26 to 75.62%, protein: 22.35 to 22.70%, ether extract: 0.65 to 0.75% and ash: 0.95 to 1.01%.

2.2.3.1.1. Effect of muscle location on proximate composition

Sogunle et al. (2010) studied two different strains of broiler and found the following values for proximate composition of breast muscles: Fibre diameter-5.36±0.03 and 5.54±0.15, crude protein-26.6±0.101 and 25.49±0.21, fat-9.72±0.021 and 9.92±0.078, ash-11.21±0.02 and 11.72±0.62 whereas the values for thigh muscles were: Fibre diameter-3.19±0.23 and 5.24±0.006, crude protein-29.92±0.101 and 28.99±0.156, fat-7.95±0.061 and 8.08±0.075, ash-13.40±0.03 and 12.42±0.682.

Bae et al. (2013) studied the breast meat quality characteristics of 5 Korean native chicken and found moisture protein fat and ash content ranging from 72.77-73.07%, 24.35-24.5%, 0.66-0.72% and 1.4-1.42% respectively.

Ali et al. (2007) studied the breast meat quality parameters of broiler aged 45 days and found moisture, protein, fat and ash content as 75.47±1.44, 22.04±0.48, 1.05±0.30 and 1.07±0.04 respectively

Almeida et al. (2006) reported the amount of moisture(g), protein(g), fat(g) and cholesterol(mg) in poultry dark meat as 77.49±1.04, 18.83±0.09, 4.08±0.60 and 80.30±2.83 (in 100gm) respectively. Kim et al. (2008) reported 75.5%, 22.0%, 1.1% and 1.1% of moisture, protein, fat and ash content respectively in broiler meat in Korea.

Chueachauychoo et al (2011) reported moisture(g), protein(g), fat(g) and cholesterol(mg/100gm) content in raw spent hen pectoralis major muscle as 74.16±0.21, 22.34±0.25, 3.11±0.59 and Fiber diameter (µm) and Sarcomere length (µm) to be 32.78±2.80 and 1.66±0.21.

Gornowicz et al (2009) experimented with Cobb 500, Hybro G+ and Ross 308 broiler birds and found that the breast muscles were found to have low intramuscular fat content (difference from 0.22 to 0.29%) and water content (difference from 0.81 to 0.83%) but higher crude protein content (difference from 0.95 to 1.46%). Smolińska (1998) also observed differences in the chemical composition of breast and leg muscles of Starbro
and Vedette broiler chickens. Those differences in the protein content amounted to 0.62% in the breast muscle and to 0.49% in the thigh muscle and the differences in fat content amounted to 1.05% and 1.06%, respectively.

Bianchi et al. (2007) studied the effect of season on the broiler breast meat quality traits and the values were: moisture: winter-74.19%, summer-75.24%, Protein: winter-23.22%, summer-22.92, Fat: winter-1.15% and summer-1.19% and ash: winter-1.45% and summer-1.36%.

2.2.3.1.2. Effect of cooking on proximate composition

Cooking can be defined as the heating of meat to a sufficiently high temperature to denature proteins (Davey et al., 1974). Temperature and cooking time have a large effect on physical properties of meat and eating quality. The components of muscle that control toughness are the myofibrillar proteins and the connective tissues proteins. During heating, the different meat proteins denature and they cause structural changes in the meat, such as the destruction of cell membrane, shrinkage of meat fibers, the aggregation and gel formation of myofibrillar and sarcoplasmic proteins shrinkage and solublisation of the connective tissue (Palka, K et al 1999) (Tornberg E, 2005). The measurement of changes occurring during cooking may be carried out by a wide range of analytical methods including textural and microstructural evaluation (Young, 1992), protein fragmentation (Garcia- Esteban et al. 2003), cooking loss or colour evaluation (Murphy, 2000). Longitudinal sections were observed in order to characterize modifications induced by the marination and cooking methods on the myofibrils meat.

Hoffman and Thong (2012) investigated the effect of cooking on proximate composition of different cut up parts of guinea fowl and found that open-roasting method produced the highest moisture in all the cuts and ash content was found to be highest in drumstick after cooking whereas the cooking methods had no effect on fat content, although breast had the lowest and thigh had the highest fat content.

2.2.3.2. Fatty acid profile

Chicken meat is categorized as white meat and from nutritional perspective it is considered superior and healthier than red meat. It has good fat profile, having low
saturated fat, and high monounsaturated fatty acids (MUFA) and polyunsaturated fatty acids (PUFA) content. It is also a good source of protein, minerals, vitamins (Ashgar et al., 1990; Sotelo and Perez, 2003). Chicken has been reported to be relatively abundant in polyunsaturated fatty acids (PUFA), including the key n-3 fatty acids in comparison to other meats. However, PUFA content (membrane phospholipids) influences lipid oxidation and therefore affects color, flavor, texture and nutritional value and quality during sub-ambient storage. Antioxidants delay or prevent lipid oxidation in meat. Kishowar et al. (2004) investigated the variability in lipid composition, antioxidant content and lipid oxidation between breast muscles from different sources and clarified the relationships.

The lipid classes in broilers are unevenly distributed in different marketable cuts, i.e. breast (white meat rich in phospholipids) and thigh (dark meat reach in triacylglycerols). In addition, n-3 PUFAs are preferentially incorporated into breast phospholipids. Consequently, feeding these fatty acids may affect the sensory quality of the above cuts differently, thus complicating further poultry meat enrichment with the polyunsaturates. The effects of different dietary combinations of PUFAs sources and vitamin E levels, on histochemical characteristics (Smolińska et al., 2002) and composition of fatty acids in poultry meat (white vs. dark cuts), have been analysed (Zanini et al. 2003, 2004).

It was found that of five sources of polyunsaturated oils (soybean, canola, sunflower, linseed, and fish), only canola and fish oil reduced the content of saturated and polyunsaturated (mainly n-6) fatty acids in the thigh meat, with fish oil increasing the content of C22:6 in this cut. Consequently, the ratio of n-6 to n-3 was reduced in the thigh meat. In contrast, the use of soybean oil increased saturated and polyunsaturated (mainly n-6) fatty acid content in the thigh meat. In both experiments, significant interactions between dietary oils and vitamin E were observed. In the breast meat, fat content was reduced by sunflower oil whereas it was elevated by linseed oil. These observations could be explained by differences in fatty acids deposited preferentially in each type of meat (Zanini et al. 2004). Hasan Elero et al. (2013) observed the meat of organic slow-growing GB-JA genotype was lighter, redder and more yellow in colour.
than the meat of S757 genotype. It seems that both genotypes had a higher fat contents and a better water-holding capacity. Body conformation especially favoring the breast meat is the most valuable portion of the chicken carcass in the market; even small differences in breast meat quality among genotypes could have a significant impact in terms of consumer demands.

The investigation of Castroman et al, (2013) showed that the organic chicken meat as produced in Uruguay has a good oxidative stability. However, this meat cannot be considered adequate for the consumers in regard to its nutritional value, at least for PUFA contents. Although the high value of the organic meat resides in its safety in regard to chemical residue and welfare of the animals, it’s also indispensable that the nutritional value of this kind of meat must be ensured for the consumers. The notion of nutritional security has to be strongly considered in the case of organic chicken meat. Most of the regulations which are worldwide applied, generally insist much on what kinds of food have to be banned and what kinds of chemical treatment have to be conducted to preserve the meat from possible contamination. A similar viewpoint has been emitted by Castellini (2005). Poultry meat may also be considered as “functional foods”, which provide bioactive substances with favorable effects on human health, like conjugated linoleic acid (CLA), vitamins and antioxidants, and a balanced n-6 to n-3 PUFA ratio (Barroeta, 2006).

2.2.3.2.1. Fatty acid profile and effect of muscle location and cooking on fatty acid content

Teye et al, (2006); Wood et al, (2006) established that the fatty acids in meat are located mainly in adipose tissue, commonly termed as “fat”. This has a role in providing volatile degradation products during cooking and contributing toward texture and juiciness in meat. The softness/hardness of fat, which is greatly influenced by fatty acid composition, affects various properties. As per study of Wood et al 2006 it was suggested that the changes in fatty acid composition can affect all these aspects of meat quality.
Hardy et al (1975) determined the effect of breed, sex and diet on the carcass composition of chickens. Male and female chicks of the Light Brahma, White Plymouth Rock, Single Comb White Leghorn, Black Jersey Giant and Dark Cornish breeds were fed three diets of widely varying calorie, protein ratios to four weeks of age. Significant differences in the quantity of moisture, protein, total lipid, ash, and fatty acid present in the total carcass was found among certain breeds.

Ali et al (2007) studied the breast meat quality parameters of broiler aged 45 days and found the MUFA and PUFA content as 1.03-1.18 and 0.77% respectively.

Almeida et al. (2006) reported that the total PUFA, n-3 PUFA, n-6 PUFA and linoleic acid (18:2n-6) was higher in dark chicken meat as compared to beef.

Cooking of meat may lead to loss or alteration of FA, especially PUFA. However, data regarding the effect of cooking processes of chicken meat on the amount and type of FA are inconsistent (Dawson et al., 1990; Lo´pez-Ferrer et al., 1999c; Grau et al., 2001b) Most of the reports do not express the FA composition of chicken meat as amount but rather as profile (percentage of total FA), which may not allow observation of the real FA losses produced by cooking.

Chueachuaychoo et al (2011) evaluated the SFA, MUFA and PUFA content in raw spent hen Pectoralis major muscle and found the amount as 34.27±0.41, 50.95±0.31 and 17.90±0.11 respectively and the result was almost similar to the findings of Liwa (2009).

Christiansen (2013) evaluated the Total Saturated Fatty Acid (SFA), total Mono Unsaturated Fatty Acids (MUFA) and total Poly Unsaturated Fatty Acids (PUFA) in breast and thigh muscles of commercial broiler strains and found the following: Breast: Total SFA-31.66%, total MUFA-45.39% and total PUFA-20.96% and for Thigh: total SFA-31.56%, total MUFA-46.47% and total PUFA-20.45%.
2.2.3.3. Cholesterol content and effect of muscle location and cooking on cholesterol content

Since the relationship between plasma cholesterol concentration and atherosclerosis was demonstrated in rabbits in 1913 (Vance and van den Bosch 2000), the interest in cholesterol content in foods has been driven by the awareness of the association between dietary cholesterol and human disease. As a result, cholesterol has become an important component in composition studies on meat and poultry products. White meat such as chicken meat is considered superior in health aspects to red meat because of comparably low contents of fat, cholesterol, and, important for men, iron. Consumers also acknowledge the relatively low price, the typically convenient portions, and the lack of religious restriction against its consumption (Jaturasitha, 2004).

Major sources of cholesterol in the human diet are meat from domestic livestock, although seafood is also rich in cholesterol. Cholesterol content of raw and cooked meat and poultry products ranges from 40 to 90 mg/100 g (Chizzolini et al, 1999; Mourot and Hermier 2001; Piironen et al, 2002; Valsta et al, 2005; Bragagnolo, 2009; Honikel, 2009). Recent data indicate upper concentrations of up to 150 mg/100 g for cooked chicken dark meat (USDA, 2011). A significant factor affecting cholesterol content of poultry is type of retail cut because of the difference between dark and white chicken meat and the presence of skin in many retail cuts. Poultry skin has the greatest cholesterol concentration compared with poultry meat or poultry fat (Dinh, et al, 2011). Cholesterol content of visible fat and breast meat is similar to or lower than that of dark meat (Ang and Hamm 1982; Smith et al, 1993; Wong et al, 1993; Baggio et al, 2002; Komprda et al, 2003).

Rule et al. (2002) found that the cholesterol concentration of chicken breast meat was greater than that of longissimus and semitendinosus muscles from bison, beef cattle, and elk. Considerable evidence suggests that within- and among-species differences in cholesterol content greatly depend on type or location of muscles (Chizzolini et al, 1999; Bragagnolo, 2009). Talat et al (2000) reported 51.90 mg/dL and 47.60 mg/dL cholesterol in the breast and thigh muscle of broiler chicken respectively.

The cholesterol content (mg/100gm) in breast and thigh muscles of broiler was found to be 77.33±2.93 and 95.43±2.62 respectively (Duraisamy et al, 2013). The concentration (mg/gm) of total lipid, total cholesterol and total phospholipid in the thigh
and breast muscles of broiler were reported to be 113.07±7.10 and 113.49±7.94, 3.87±0.36 and 1.71±0.21 and 46.88±5.50 and 54.58±4.14 respectively (Sinku et al, 2003).

2.2.4. Physico-chemical qualities of Broiler meat:

Bae et al. (2013) studied the breast meat quality characteristics of 5 Korean native chicken and found pH and Water Holding Capacity (WHC%) ranging from 5.77-5.84 and 64.24-65.54% respectively. Several studies have reported strong correlations between muscle pH, colour and water-holding capacity (Van Lack et al. 2000, Quiao et al. 2002, Barbut et al. 2005).

The range of pH, Water Holding Capacity (WHC ml/100gm) and fiber diameter of the breast and thigh muscles of broiler was found to be 5.95±0.04 and 6.00±0.04, 13.57±0.30 and 13.57±0.79 and 34.16±1.02 and 25.14±1.15 respectively (Sinku et al. 2003).

Kokoszynski et al. (2013) studied the carcass characteristics of different broiler birds and found : pH (15 minutes postmortem): 5.79-6.12 in breast muscles and 6.38-6.45 in leg muscle, WHC(%): 57.9-60.9 in breast muscle and 69.2-71.6 in leg muscles.

2.2.5. Minerals and Heavy metal content of broiler meat:

From the perspective of human nutrition, poultry meat, in addition to large amount of easily assimilated animal protein and vitamins, is a valuable source of minerals (Lombardi-Boccia et al. 2005). The level of those compounds, may vary not only according to the micro- and macro-element content of feeds but also according to the way animals are housed, their breed, sex and health, slaughter procedures, and type of muscle (Doyle 1980, Horbańczuk et al. 1998, Sales and Horbańczuk 1998, Zapata et al. 1998, Sadoval et al. 1999, Lombardi-Boccia et al. 2005, Pesut et al. 2005, Skrivan et al. 2005).

Mineral components play an important role in the metabolism of skeletal muscles, and some elements (such as Na, Ca, K, P and Mg) play a vital role in enzymatic processes and are responsible not only for normal muscle function but also for the course and extent of postmortem changes in muscles (Podgórska et al. 2001, Keeton and Edy, 2004).
Bockman et al. (1990) categorized heavy metals as metallic elements with high specific weight, often toxic to mammals. Heavy metals could be categorized into three groups according to their toxic levels i.e. toxic (Cd), moderately toxic (Pb, Ni, Hg) and low toxic (Zn, Fe, Mn, Cu). It is a well known fact that vulnerability of man to heavy metal toxicity is high when compared to many other animals and plants.

A study by Mohanna and Nys [1998] indicates, for example, that the age of chickens has a significant effect on the level of trace elements (Zn, Fe, Mn, Cu) in whole body, the concentration of which decreases significantly as broilers grow old. Likewise, Doornenbal and Murray (1981), Kotula and Lusby (1982) and Lin et al. (1989) consider the age to be one of the major factors affecting the mineral content of animal tissues. Unfortunately, studies upon growth-related changes in macromineral concentrations and technological properties of meat are limited, especially in poultry.

The Mean mineral content (gm/kg tissue) of breast and thigh muscles of broilers aged from 35-42 days were recorded to be: Na: 0.41-0.46, Ca: 0.03-0.04, K: 4.01-4.3, P: 2.28-2.45 and Mg: 0.3-0.34 in case of breast muscle and Na: 0.67-0.75, Ca: 0.0.05, K: 2.77-3.34, P: 1.84-2.06 and Mg: 0.23-0.25 in case of leg muscles (Poltowicz and Doktor, 2013).

Similar to other studies (Lawrie 1990, Demirbas et al. 1999, Podgórski et al. 2001), K was quantitatively the most important mineral in chicken meat, followed by P and Na. According to Koreleski (2002), the low level of dietary minerals causes deficiency conditions, with decreased mineral content of blood serum, liver and other internal organs as well as meat. It is, therefore, possible that the lowest level of macrominerals in the leg muscles of the youngest and then fastest growing chickens resulted from the inadequate supply of these compounds in feed, or from their insufficient absorption and assimilation from the digestive tract of rapidly growing broilers. Nevertheless, it is surprising that the intensity of chicken growth had a greater impact on changes in the mineral levels and quality of leg muscles rather than breast muscles, because the latter are considered to be more susceptible to quality changes of this type. Paltowicz and Doktor (2013) also found no correlation between the retention of minerals in breast muscles with the other meat quality traits. When comparing the most valuable two types of broiler muscles for the consumer for their mineral content, they also found
that breast muscles were a richer source of K, Mg and P, and leg muscles contained more Na. The level of Ca in both muscle types did not differ significantly between ages, although this element showed a trend towards higher concentration in leg muscles. According to Addis (1986), the higher content of calcium in dark meat may be associated with a greater demand of leg muscle contraction as compared to that in light breast muscle.

Zapata et al. (1998) reported values of 4.71, 224.28, 28.59, 327.99 and 46.83 mg/100 g tissue for Ca, P, Mg, K and Na, respectively, in broiler chicken light meat, and of 5.69, 191.78, 20.17, 280.25 and 66.11 mg/100 g tissue, respectively, in dark meat. According to Hermida et al. (2006) the average macromineral concentration in muscles depend not only on the type of cuts, but on other factors which are often not reported. It has long been recognized that the heavy metal accumulation in soil may result in potential health risk to plants, carnivores and humans through indirect or direct pathway, or via food chain (Heikens et al., 2001; Prince et al., 2001; Blakbern, 2003). Heavy metals from man-made pollution sources are continuously released into aquatic and terrestrial ecosystems and therefore, the concern about the effect of anthropogenic pollution on the ecosystems is growing. Contamination with heavy metals is a serious threat because of their toxicity, bioaccumulation and biomagnifications in the food chain (Demirezen and Uruc, 2006). These pollutants often have direct physiological toxic effects because they are stored or incorporated in tissues, sometimes permanently (Bokori et al, 1996; Mariam et al, 2004). Gradjean (1986) reported that the production of phosphate fertilizer could be considered as main source for cadmium in the environment. Ghaedi et al. (2008) reported that arsenic containing pesticides and other agricultural products can lead to the accumulation of arsenic and other toxic metals in soils and plants and resulting in trace amounts of toxic metals, including arsenic found in food and feedstuffs.

Zhuang et al (2009) the quantum of accumulation of few heavy metals in broiler birds and found that the concentration of Pb was 0.58mg/kg and 3.62 mg/kg in muscle and liver respectively and the level of Cd was 0.1 mg/kg and 0.5 mg/kg in muscle and liver.
Iwegbue et al. (2008) surveyed 7 different localities in Nigeria and studied concentration (mg/kg) of Fe, Cu, Zn, Ni, Mn, Cd, Pb and Cr in chicken meat tissues and the results were: Fe: 23.52±1.24 to 92.72±4.61, Cu: 0.01±0.00 to 5.15±0.5, Zn: 6.12±0.15 to 33.21±0.34, Ni: 1.20±0.16 to 9.02±0.12, Mn:0.01±0.00 to 0.45±0.17, Cd: 0.01±0.00 to 1.27±0.24, Pb: 0.01±0.00 to 4.60±0.92, Cr: 0.29±0.08 to 4.83±0.22. Mariam et al. (2004) reported Cd content of 0.33 mg.kg-1, 0.37 mg.kg-1 and 0.31 mg.kg-1 for lean meat of beef, mutton and poultry respectively.

The mean concentrations of Cd measured in poultry breast and leg muscle were relatively low (0.0187; 0.021 mg/kg, respectively). The mean concentrations of Cd were slightly lower in breast than in leg muscle. Braeckman et al. (1997) reported that no major differences have been demonstrated in Cd content of different muscles (breast muscle, leg muscle). Cd mean contents in poultry meat were found to be 0.009 mg/kg in the central database from a non-contaminated area of the Slovak Republic (Sokol et al., 1998). Skalická et al. (2002) surveyed cadmium (Cd) levels in poultry meat from polluted area of Eastern Slovakia. The mean values of cadmium in breast and leg muscle, liver and heart were 0.019; 0.021;0.061; 0.099 mg/kg, respectively. On the basis of their results of cadmium analyses, it follows that its levels in poultry meat are below the highest permissible hygienic limits for Cd. Shah (2009) found that the concentrations of total arsenic in different tissues of broiler chicken were in the range of 2.19-5.28, 2.15-5.22, 2.97-7.17 and 2.68-6.36 µg/g for leg, breast, liver and heart tissues respectively.

Rehman et al. (2012) analysed meat tissues from five different commercial broiler farms in Pakistan and found the concentration (mg/kg) of Cu: 167±1.96 to 340±3.44, Mn: 9±1.05 to 102±6.11 and Fe: 808±5.47 to 11009±10.

2.2.6. Pesticide residues in broiler meat:
Organochlorine pesticides (OCPs) have been used in the public health sector for disease vector control and in agriculture to control crop pests for the past several decades globally. They are characterized by low water solubility and high lipid solubility, leading to their bioaccumulation in fatty tissues. Therefore, they can accumulate in human body fats and the environment posing problems to human health (Ejobi et al., 1996). The OCP residues may concentrate in the adipose tissues and in the blood serum of animals leading
to environmental persistence, bioconcentration and biomagnification through the food chain. Pesticide contamination of chicken and meat resulting from feeding a diet containing a low concentration of pesticides is a well established fact (Noble, 1990; Aulakh et al., 2006). OCP residues in feed may be ingested by herbivores and eventually find their way into the animal body which ultimately results in the contamination of milk, meat, eggs, etc. consumed by human being. Thus human body also gets contaminated. A study conducted in Tianjin, China, revealed that inhalation and dermal contact contributed to only 5.1% and 13.5% of the total intakes of DDTs and HCHs by adults, while ingestion through diet was responsible for 94.9% and 86.5% of the total, respectively. The importance of eggs, chicken and meat consumption as a source of OCP has been established worldwide (Al-Omar et al.,1985; Kannan et al., 1992a,b; Antonio et al., 1994; Osibanjo and Adeyeye, 1997; Barkatina et al., 1999; Aulakh et al., 2006; Darko and Acquaah, 2007; Corrigan and Seneviratna, 2008; Fontcuberta et al., 2008; Windal et al., 2009).

Previously, the mean concentration of DDT and HCH (mcg/g wet wt) in meat collected from various locations in India are given below:

<table>
<thead>
<tr>
<th>Year</th>
<th>Location</th>
<th>DDT</th>
<th>HCH</th>
<th>References</th>
</tr>
</thead>
<tbody>
<tr>
<td>1975-76</td>
<td>Calcutta</td>
<td>1.5</td>
<td>1.2</td>
<td>Mukherjee et al. (1980).</td>
</tr>
<tr>
<td>1979</td>
<td>Delhi</td>
<td>1.0</td>
<td>NA</td>
<td>Sharma et al. (1979).</td>
</tr>
<tr>
<td>1979</td>
<td>Bombay</td>
<td>NA</td>
<td>0.6</td>
<td>Banerjee. (1979).</td>
</tr>
<tr>
<td>1980-81</td>
<td>Punjab</td>
<td>0.25</td>
<td>0.19</td>
<td>Singh and Chawla (1988).</td>
</tr>
<tr>
<td>1981-83</td>
<td>Uttar Pradesh</td>
<td>0.24</td>
<td>0.20</td>
<td>Kaphalia et al. (1982).</td>
</tr>
<tr>
<td>1989</td>
<td>Various states</td>
<td>0.1</td>
<td>0.48</td>
<td>Kannan et al. (1992b).</td>
</tr>
</tbody>
</table>

Ahmad et al. (2010) analysed the organochlorine pesticide residues in egg, chicken, lamb and beef meat and found (in mg/kg concentration) DDT, Dieldrin, α-Endosulfan, α-HCH and Hexachlorobenzene concentration of 104.6±8.8, 93.9±2.5, 93.3±2.9, 91.3±2.4 and 91.3±2.7 respectively in chicken meat.

According to the Prevention of Food Adulteration Act and Rules as on 01.10.2004, the maximum residue level (ppm or mg/kg) of pesticide residue in meat and
poultry in India are: Aldrin and dieldrin-0.20, DDT-7.00, Lindane-2.0, Chlorpyriphos-0.10 and 2,4D-0.05 (Jadhav and Waskar, 2011).

However, Sallam and Morshedy (2008) showed that heat treatment of meat (boiling for 1.5 h) produced overall reductions of 40.4%, 55.0%, 32.4%, 33.5%, 29.2% and 38.2% in DDTs, lindane, dieldrin, aldrin, endrin and HCB contents, respectively. This could be attributed to the volatility of these compounds and to the elimination with the fat rendering induced by high temperatures.

2.3. GOAT MEAT

Goats are widely distributed around the world (Webb et al., 2005). Goat meat (chevon) is popular with the greatest production and consumption in Asia and Africa (Kannnan et al., 2001). Chevon is the meat from older goat kids slaughtered when 6 to 9 months of age and weighing from 50 to 75 pounds (Julio, 2008). There is a worldwide tendency for rapid increase in demand for goat meat (Gipson, 1998; Stankov et al., 2002). It is a low-fat, nutritious red meat alternative for health conscious consumers owing to its low cholesterol content (Das and Rajkumar, 2010). 3 oz cooked / roasted goat meat contains 2.8g fat, 0.79g saturated fat, 23g protein, 63.8mg cholesterol and an energy value of 122 calories (USDA, 2001). Goat meat has an immense market potential, as it could become an ideal choice for health conscious consumers (Johnson et al., 1995) because, in the same cuts, goat meat has 50-65% less fat content than beef and 42-59% less fat than lamb meat (Addrizzo, 1994) as well as it is a good source of desirable fatty acids and richer source of polyunsaturated fatty acids (e.g., C18:2, C18:3 and C20:4) than beef and sheep meat. Average percentages of desirable fatty acids (all unsaturated fatty acids and C18:0) in goats are between 61 and 80, relatively higher than values for beef and lamb and similar to levels for lean pork (Banskalieva et al., 2000). Adam et al. (2010) reported that the percentage of saturated fat in goat meat is 40% less than poultry without skin; 85% lower than beef; 100% lower than pork and 90% lower than lamb. This is an important factor in reducing the risk of cardiovascular diseases (Stankov et al., 2002). Cholesterol content (62–65 vs 73–78 mg/85 g meat) and saturated fatty acid levels (0.79–1.01 vs 6.8–8.7 g/85 g meat) of cooked goat meat are lower when compared to other red meats (USDA, 1989). Additionally, goat meat has higher levels of iron (3.2 mg) when
compared to a similar serving size of beef (2.9 mg), pork (2.7 mg), lamb (1.4 mg), and chicken (1.5 mg). Goat meat also contains higher potassium content with lower sodium levels. The amino acid profile of chevon shows a close resemblance with the analyses of beef, pork and lamb (Anaeto et al., 2010). It is high in protein and low in fat, which makes it an attractive red meat alternative to consumers (Dhanda et al., 2003b).

Goat carcasses have significantly more protein and essential amino acids than sheep carcasses (Sheridan et al., 2003). Goat kids of White Improved breed and ram lambs of the Polish Lowland breed fattened up to 150 days were studied by Niedziółka and Pieniak-Lendzion (2006), where, goat kid meat showed significantly higher content of protein (20.21 %) and mineral compounds (1.13 %) and lower fat content (2.28 %). The analyzed intramuscular fat of goat kids was characterized by a more beneficial proportion of monounsaturated and polyunsaturated acids than the ram lambs. In the experiment, the proportion of unsaturated to saturated fatty acids in goat meat (1.69) was more favourable than lamb (1.22). The results of the study showed that goat meat has better quality than lamb. Proportion of unsaturated to saturated acids is a significant indicator of fat quality. In human diet the proportion should be equal to 2 (Gruszecki et al., 1999; Pieniak-Lendzion et al., 2000).

Carcass measurements, commercial cuts and chemical composition of the meat of 32 Boer goat (BG) kids and 32 South African Mutton Merino (MM) lambs were investigated by Sheridan et al. (2003). BG had significantly more moisture and protein and lower fat and energy values than MM lambs. BG had significantly higher concentrations of 11 of the 18 measured essential amino acids in their 8-9-10-rib cuts than the MM. Goat carcasses had higher Ca, K, Mg, Na and P levels than sheep carcasses, regardless of the diet offered. BG had a lower carcass cholesterol content than lamb (66·77 v. 99·28 mg/100 g, respectively). In terms of nutrient composition, meat from young goats is not inferior to that of lamb and since it has a higher protein% and lower fat, cholesterol and saturated fatty acid than lamb it may be considered a healthy alternative.
According to Simela et al. (2008), most sensory evaluations of chevon that employed trained taste panels generally showed that chevon and chevon products are of high quality.

### 2.3.1. CARCASS CHARACTERISTICS

#### 2.3.1.1. Effect of breed on carcass characteristics

Dressing percentage, which is an important trait for carcass evaluation, is influenced by age, breed, sex, plane of nutrition, management system etc. (Das and Rajkumar, 2010). However, Johnson et al. (1995) reported that breed type had no (P>0.05) apparent influence on the yield of dressing percentage. On the other hand, a study conducted by Das and Rajkumar (2010) revealed that breed has no significant effect on slaughter weight, carcass measurements, and fat thickness of three goat breeds (Barbari, Jamnapari and Marwari) except in case of dressing percentage and fore cannon. Dhanda et al. (2003a) reported significant \((P<0.05)\) differences between different genotypes in dressing percentage. They also reported significant differences between different goat breeds in eye muscle area, which is in agreement with the findings of Johnson et al. (1995). Sebsibe (2006) also indicated that genotype affected dressing percentage and other carcass characteristics. Dressing percentage on slaughter weight basis varied from 38.6% in small sized Black Bengal goats to 49.7% in large sized Beetal (Dhangar et al., 1992).

Kadim and Mahgoub (2012) found differences in dressing percentage based on full and empty live body weight which were in range of 39.5%-41.8% and 53.3%-56.6% respectively among three Omani goat breeds.

Sengar (1979) and Mishra (1979) reported a range of 45-50% dressing % in four major Indian goat breeds (Jamunapari, Barbari, Beetal and Black Bengal). Kesava Rao et al. (1988) also reported a dressing % of 48.8 for goats slaughtered in the market (Jamunapari, Barbari and their crosses). Johri and Talpatra (1971) have reported the dressing percent of 44.2 in Jamunapari goats. The hot carcass weight (kg), dressing percentage and bone percentage of Jamunapari goat is 6.47±0.43, 39.16±0.84 and 11.4% respectively (ICAR, 2002). Irrespective of age, the mean slaughter weight, hot carcass weight and dressing percentage were higher in Tellicherry males (18.53 kg, 8.3 kg and
43.94%, respectively) than Jamunapari males (17.02 kg, 7.23 kg and 41.76%, respectively) as reported by Sivakumar et al. (2006). Amin et al. (2000) found 4.9±0.21 kg hot carcass weight; 38.8±0.44% dressing percentage and 5.7±0.20 cm² eye muscle area in case of randomly bred Black Bengal goats. In case of Black Bengal goats selected for growth, those values were 6.7±0.21 kg, 40.1±0.44% and 7.2±0.20 cm² respectively. There was significant correlation (p<0.01) between eye muscle area and hot carcass weight. Singh et al. (1983) and Raghavan (1988) also reported that eye muscle area was highly associated with hot carcass weight. The mean of hot carcass weight and eye muscle area were 5.82±0.27 kg and 6.50±0.25 cm² respectively in case of Black Bengal goats (Rahman, 2007b). Chowdhury and Faruque (2004) reported dressing percent of Black Bengal goat between 181 and 365 days of age was 46.4%. Dressing percentage 43.71% was reported by Asaduzzaman et al. (2009) in case of Black Bengal goats. Hot carcass weight was found to be in the range of 5.82± 0.27 kg to 6.75±0.18 kg and body length in the range of 49.50±0.49 cm to 59.19±1.46 cm in Black Bengal goats by Rahman. (2007a).

Optimum slaughter age for Black Bengal goat reared under semi-intensive management with adequate feeding and management would be about 9 months when their live weight, warm carcass weight, edible and saleable weight of carcass can be about 16.74, 7.28, 12.05 and 13.81 kg, respectively (Chowdhury and Faruque, 2004). According to Chowdhury and Faruque (2004), live weight, carcass weight, edible weight and saleable weight of castrated Black Bengal goat at one-year onward ranges from 20-22, 9.4-10.5, 14-16 and 16.6-18.8 kg, respectively.

Das and Rajkumar (2010) reported that breed had no significant effect on slaughter weight of goats. They also found that there was no significant differences in breed and muscles in meat chemical composition among Barbari, Jamunapuri and Marwari breeds, cooking loss percentage varied from 36-38% and the cholesterol content of Jamunapuri breed was higher (71.76 mg/100gm).

Sebsibe et al. (2007) indicated that breed affected the carcass characteristics and proportions of the primal cuts of the three Ethiopian goat breeds, however, diet had no significant (P > 0.05) effect on the physical composition and proportions of the primal
cuts of the carcass. Reddy and Raghavan (1987) also reported that diet had no significant effect on relative proportions of various carcass cuts or on lean, bone and fat % in chilled carcass of goats. The % of lean was highest in leg and lowest in shank and breast. Shoulder cut had the lowest bone% and the highest fat%. The tissue distribution of goat carcasses averaged 63% lean, 22% bone, 10% intermuscular fat and 5% subcutaneous fat as reported by Simela (2005). Carcass quality is mainly influenced by the distribution of muscle, fat and bone in the carcass (Dhanda et al., 2003b).

Sivakumar (2013) reported significant (P<0.05) influence of slaughter weight on tenderness of goat meat which decreased with higher slaughter weight.

Chowdhury and Faruque (2004) reported that the average proportion of different carcass cut of Black Bengal goats, reared under semi-intensive management were - round 27%, rump 7%, loin 10%, ribs (6-12th) 14%, shoulder 21%, Neck 7%, chest 14%. Thigh and shoulder constituted about 48.3% of the cold carcass weight. Dhanda et al. (2003b) studied the distribution of muscle, fat and bone in the carcasses and fatty acid composition of adipose tissue obtained from six goat genotypes (Boer×Angora, Boer×Feral, Boer×Saanen, Feral×Feral, Saanen×Angora and Saanen×Feral) and two slaughter weight groups (Capretto and Chevon). They reported that the contributions of primal cuts (shoulder, long leg, ribs, neck and flank) as a percentage of the carcass side weight were: 19, 33, 24, 11 and 13%, respectively, with no significant (P>0.05) differences between genotypes. The flank had the lowest percentage of muscle and highest percentage of total fat (sum of subcutaneous and intermuscular fat) while the shoulder and long leg cuts had the highest percentage of muscle, and lowest percentage of fat compared to other primal cuts. Composition of goat carcasses indicated significant (P<0.05) differences in the muscle, fat and bone contents between genotypes. Elangovan et al (2010) revealed that the bone and fat ratio differs significantly (P<0.01) among the different cuts of Kanni goat carcass.

Kadim et al. (2004) indicated that breed influenced the growth rate, carcass and meat quality of goats. Simela et al. (1999) found that the mean relative proportions of tissues were 63.5 ± 5.04% lean, 19.1 ± 2.50% bone, 3.8 ± 2.89% subcutaneous fat and 11.8 ± 4.34% intermuscular fat, irrespective of sex in case of marketed Matebele goat.
from south-western Zimbabwe. Sen et al. (2004) recorded 76.77% of meat tissue and 6.93% of fat tissue in the leg portion of goats. The smaller Dhofari goat had a higher proportion of muscle but lower proportion of bone in the carcass than larger Batina goats as reported by Mahgoub and Lu (1998).

Effect of breed on carcass measurements and meat quality characteristics of lambs were investigated by Ekiz et al. (2009) using Turkish Merino, Ramlic, Kivircik, chios and Imroz breed and significant effect of breed on carcass measurements and conformation indexes were found. Several authors reported an increase in carcass measurements and conformation indexes parallel to increasing carcass weight (Diaz et al., 2002 and Santos et al., 2007). More than 63% of the carcass consisted of lean muscle and an average of 20% of the carcass consisted of bone (Sainsbury, 2009). According to Abdullah and Qudsieh (2008) the leg and shoulder cuts of South African lamb are higher in muscle.

Simela et al (2012) reported that the tissue distribution of the South African indigenous goat carcasses averaged 63% lean, 22% bone, 10% intermuscular fat and 5% subcutaneous fat and within the goat carcasses, the hind limb seemed to be most ideal for high lean, low fat, high value cuts.

Yalgintan et al (2012) reported variations in muscle percentage among different carcass joints such as shoulder (56-59%), loin (57-66%) and long leg (57-61%).

2.3.2. NUTRITIONAL PROFILE

2.3.2.1. Proximate composition

2.3.2.1.1. Effect of breed on proximate composition

Asaduzzaman et al. (2009) reported that the percentage of moisture, crude protein, ether extract and ash contents were 72.79, 21.90, 3.72 and 1.15 for Black Bengal goat. A significant influence of the breed on the crude protein, fat and water content of carcasses from British Saanen goats and their crosses with Boer and Anglo-Nubian goats were observed by Gibb et al. (1993). Similar result was found by Dhanda et al. (2003b) in respect of protein content. However, according to Das and Rajkumar (2010), there were
no significant differences between breeds and muscles in meat chemical composition among three Indian goat breeds (Barbari, Jamnapari and Marwari).

Sebsibe (2006) revealed that genotype significantly influenced the carcass fat, crude protein content and also the fatty acid composition of meat in case of Ethiopian goats. However, Mahgoub et al. (2005) reported no breed differences in chemical composition of carcass of Omani goats. Significant differences in moisture, protein and mineral substance content among the breeds and crossbreeds of young goats at the two slaughtering ages were not observed, whereas significant differences were present in regard to the fat content of meat (Stankov et al., 2002).

Rahman et al (2012) reported that the average moisture content in three goat breeds, namely Kameri, Pateri and Tapri was 73.02 ± 0.732%, and the average ash content was 1.40 ± 0.049% and the differences were highly significant (P<0.01) among the different goat breeds. Jibir et al (2010) found goat meat contains an average of 75.59, 19.19, 3.67 and 1.55% moisture, protein, fat and total ash, respectively and none of the nutrients was affected significantly (P>0.05) by breed, age and fasting status.

Asaduzzaman et al (2009) reported that the percentage of moisture, crude protein, ether extract and ash contents were 72.79%, 21.90%, 3.72% and 1.15% for Black Bengal goat. Carcass chemical composition of Black Bengal and crossbred goats showed that moisture, crude protein and ash content did not differ significantly (p>0.05) between Black Bengal and crossbred goats. But the fat content of crossbred goats was significantly higher (P>0.01) than that of Black Bengal goat. This might be due to the genotypic effect or feeding of more concentrate feeds to crossbred goats as compared to Black Bengal goat.

Sebsibe (2012) reported that in a good quality chevon, the pH ranges from 5.4 - 5.7 and the approximate composition of the goat meat is about water 75%, protein-19%, lipid-2.6% and 0.65% minerals and breed has a direct influence on the fatty acid content of the meat which in turn affects the nutritive value and sensory characteristics of meat. He also reported that breed significantly affects the cooking loss and in chevon, it ranges from 32.5-51.5%.
2.3.2.1.2. Effect of muscle location on proximate composition

According to Lawrie (1998), it is feasible that significant differences may exist between specific muscle locations in the carcass or that breed and age has an effect. Amino acid varies between different parts of the carcasses (Lawrie, 1998). The loin and breast muscles were found to be the best in respect of protein content (Biswa et al., 2010).

Looking at the differences between raw and cooked South African lamb, van Heerden (2007) reported that the nutrient components exhibiting the greatest differences between the three raw cuts (leg, loin and shoulder) were moisture, total fat, energy, C14:0, C16:0 and C18:0 saturated fatty acids, C18:1n9c monounsaturated fatty acid and C18:2n6c polyunsaturated fatty acid.

Sainsbury (2009) studied three cuts (leg, loin and shoulder), taken from both sides of carcasses of two breeds of sheep (Dorper and Merino) which were used to determine the cooked (left side) and raw (right side) physical and nutrient composition. There were no significant differences in the nutrient values for the vitamins, fatty acids and cholesterol when comparing the three cooked cuts. Cooked loin cut contained the most protein (27.79 g / 100 g edible portion) of the three cooked cuts. The cholesterol content for all three cooked lamb cuts was higher, although not significantly than the raw cuts, with the shoulder cut containing the highest cholesterol. Loin cut contained higher fat and cholesterol than cooked leg and shoulder cuts in South African mutton.

Ilie et al (2011) found 73.5% moisture, 19.8% protein, 2.88% fat and 1.52% ash in adults goats samples.

Dunne et al. (2008) reported that M. Extensor carpi radialis of steers had higher moisture concentration, lower protein and intra-muscular lipid concentration than M. Longissimus dorsi.

The basic chemical composition of kid meat varied depending on both the muscle group and the breed (Mioc et al., 2001). The average content of fat in back muscles of Saanen and Alpine kids was 1.01 and 1.16 %, respectively; in thigh muscles it was 1.41 and 1.45 %, while the highest fat content was found in shoulder muscles (1.55 and 1.64...
Both breeds had a significantly higher fat content in thigh and shoulder muscles than in back muscles. The two breeds showed no significant differences in the chemical composition of different muscle groups. Adam et al. (2010) reported that the type of diet had no significant effect (p>0.05) on the chemical composition, WHC and cooking loss of meat from Nilotic kids.

Islam et al. (2010) reported that the ranges of crude protein (CP) content of goat carcass (20.78-27.71%) differed significantly (p < 0.01) and leg portion contained higher CP than other portion. Fat, moisture, ash content of different cuts differed significantly (P < 0.01).

Atay et al (2011) reported an average moisture, ash, protein and fat values of meat samples as 75.70, 1.04, 18.91 and 3.23%, respectively and the pH values of meat samples were found as 5.71 in Hair goats.

Van Heerden (2007) studied three cuts (leg, loin and shoulder), taken from both sides of carcasses of two breeds of sheep (Dorper and Merino) which were used to determine the cooked (left side) and raw (right side) physical and nutrient composition. The moisture content of the raw leg cut was significantly higher and fat content significantly lower than the shoulder and loin cuts, which contained the highest fat value. On the other hand, van Heerden (2007) reported that the cooked loin cut (27.8 g / 100 g) had significantly (p < 0.01) more protein when compared to the leg (24.5 g / 100 g) and shoulder cuts (23.15 g / 100 g). The cooked shoulder had significantly more fat than the cooked loin and leg cuts. A significant difference was found for ash content, with the cooked loin cut having the highest ash content, followed by the cooked shoulder cut.

**2.3.2.1.3. Effect of cooking on proximate composition**

According to Ono et al. (1984), the differences in the amount of nutrients between raw and cooked meat cuts can be used to calculate nutrient retention in the cuts. Endpoint temperature of cooking leads to moisture loss and thus an increase in concentration of some nutrients and a decrease in the heat-labile nutrients, and again has an effect on the nutrient content (Jamora and Rhee, 1998). Cooking resulted in increase in protein, fat and cholesterol concentration of cooked cuts in South African mutton. A significant
difference in protein, fat and ash, was apparent between the raw and cooked fat. The moisture and protein content differed significantly for each of the three cuts between the raw and the cooked state, cooking results in increase in protein and cholesterol content (Sainsbury, 2009).

Van Heerden (2007) concluded that nutrients showing the greatest differences between raw and cooked treatments were protein, total fat, cholesterol, C16:0, C18:0 and C20:0 saturated fatty acids and C18:1n9c MUFA in South African lamb. Moisture losses due to cooking resulted in an increase in the protein and cholesterol concentrations of the cooked cuts. Protein content was significantly higher in the cooked lamb meat (25g/100g) when compared to the raw meat (18g/100g) as reported by Van Heerden (2007). The cooked shoulder cut had the highest SFA (C14:0 – 0.59 g /100 g and C16:0 – 2.05 g / 100 g) content except for C18:0 that was the lowest (0.78 g 100 g) compared to the three samples. The cooked shoulder contained the highest C16:1 and C18:1n9t fatty acids with the least C18:1n9c MUFA as well as PUFA C18:2n6t and C18:2n6c.

2.3.2.2. Fatty acid profile

Fatty acids are the major component of lipids. The fatty acid composition of fats determines its degree of saturation, and therefore, significantly affects its quality (Solaiman et al., 2011). The analysis of fatty acids has become increasingly important, because more people have become aware of their nutritional and health implications (O’Fallon et al., 2007). Physical and chemical properties of lipids affect eating and keeping qualities of meat. Meat flavor is also influenced by fatty acid composition (Melton, 1990). The major fatty acids in muscle lipids of goats are oleic (C18:1), palmitic (C16:0), stearic (C18:0) and linoleic (C18:2). Saturated fatty acids (SFA) include mainly myristic (C14:0), C16:0 and C18:0; monounsaturated fatty acids (MUFA) are primarily palmitoleic (C16:1) and C18:1; and polyunsaturated fatty acids (PUFA) consist largely of C18:2, linolenic (C18:3) and arachidonic (C20:4). Percentages were between 28 and 50% for C18:1; 15 and 31% for C16:0; 6 and 17 % for C18:0; and 4 and 15% for C18:2. The concentration of SFA in goat muscles varied from 29 to 54% (Banskaliева et al., 2000). Oleic acid is the main fatty acid in both goat muscles and fat depot as reported by Banskaliева et al. (2000) and Pena et al. (2009). It is generally accepted that plasma
cholesterol concentration is influenced by the fatty acid composition of dietary fat. Lauric (C12:0), C14:0 and C16:0 raise the plasma cholesterol level (Denke and Grundy, 1992); whereas, C18:0 does not appear to have such an effect and is considered `neutral' and C18:1 (oleic acid) decreases blood cholesterol content. The most abundant fatty acids in goat muscle were oleic acid (C18:1), linoleic acid (C18:2) and C16:0, respectively. The three made up 74.4% of the total fatty acid content in Longissimus lumborum muscle (Simela, 2005). Pena et al. (2009) also reported the main fatty acids identified from the intramuscular fat were oleic acid (32.6-35.9%), palmitic acid (20.3-21.4%) and stearic acid (11.3-14.3%) which was in the range of those reported by Banskalieva et al. (2000) in goats. A greater ratio of polyunsaturated to saturated fat and a lower ratio of omega-6 to omega-3 in meat would be desirable to lower the incidence of metabolic diseases such as heart disease, inflammation and mental health (Wood et al., 2003 and Scollan et al., 2001).

2.3.2.2.1. Effect of breed on fatty acid profile

Breed differences in fatty acid composition were observed by Park and Washington (1993) in Alpine and Nubian goats. They noted that saturated fatty acid in muscle longissimus dorsi and biceps femoris were higher for Nubian than for Alpine goats, and the opposite was true for MUFA levels in longissimus dorsi muscle and PUFA in biceps femoris muscle. Similar results were found by Sebsibe (2006) in three Ethiopian goat breeds. Oleic acid is the most predominant fatty acid, followed by palmitic and stearic acid, whereas, C10:0, C12:0 and C15:0 were not detected in goat muscles (Sebsibe, 2006). Celik and Yilmaz (2010) found that there was no significant difference in fatty acid composition between two genotypes (Awassi and Turkish Merino × Awassi (F1) lambs) and sex groups of lambs. Fatty acid content of body tissues was affected by nutrition as was evidence in goats grazing on pasture having more unsaturated intermuscular fat than those fed grain (Rhee et al., 2000).

Madruga et al. (2009) established that genotype has got no significant effect on chemical composition and lipid profile (cholesterol and phospholipids) of goat meat. He also identified ten fatty acids in the goat meat chromatograms which were as follows: six saturated fatty acids (SFA), two monounsaturated fatty acids (MUFA), and two
polyunsaturated fatty acids (PUFA). Among the ten fatty acids identified, four fatty acids constituted 95% of the total areas of the chromatograms: C18:1, C18:0, C16:0 and C18:2. Oleic acid (C18:1) presented the largest contribution to the fatty acids profile in the meat of goats.

Sikora and Borys (2006) studied the effect of age and breed of goat kids on the lipid profile of muscle tissue and the study showed that as the kids grew older from 60 to 180 days, the content of total SFA, including mainly saturated acids (C16:0 and C18:0), did not change significantly. In terms of UFA, there was a significant increase in the content of MUFA (including the dominant oleic acid C18:1) and a concurrent decrease in the content of all PUFA with the age of the kids. Comparison of the relevant data for pure breeds of goats in a review by Banskalieva et al. (2000) shows considerable differences in the lipid profile of intramuscular fat in kids of different breeds. Goat genotypes had a significant influence on the fatty acid profiles of the intermuscular fat (Dhanda et al., 2003b).

According to Pena et al. (2011), genotype has a great influence on lipid profile. Concentrations of 15:0, 16:0, 18:2n-6 and 22:6n-3 fatty acids did not differ (P>0.05) between genotypes. While the proportions of 17:0 and 18:0 were clearly higher in meat from both Criollo Cordobes muscles (P<0.001), than the meat from Anglo Nubian goat kids (P=0.026).

2.3.2.2.2. Effect of muscle location on fatty acid profile

There are differences in fatty acid composition among the various muscles of goats (Banskalieva et al., 2000). Purchas and Zou (2008) reported that fatty acid concentrations, expressed as percentages of total fatty acid, for saturated fatty acids, monounsaturated fatty acids and polyunsaturated fatty acids, showed many significant muscle effects.

Barton et al. (2008) also noted significant differences in fatty acid composition between muscles. Longissimus thorasis muscle of Anglo Nubian goat meat had lower SFA content (P=0.003) than semitendinosus muscle (Pena et al., 2011). Enser et al. (1998) found that relatively white muscle longissimus dorsi in beef was generally lower
in PUFA compared with the hindlimb muscle *gluteus medius*. The *m. semimembranosus* and *m. triceps brachii* in lambs contained 12±19% more PUFA than *m. longissimus dorsi* (Solomon *et al.*, 1991). Raw leg cut contained the lowest fatty acid content (van Heerden, 2007).

### 2.3.2.2.3. Effect of cooking on fatty acid profile

Cooking of meat may lead to loss or alteration of fatty acid, especially PUFA (Cortinas *et al.*, 2004). High temperatures during cooking increase lipid oxidation, which may result in a higher reduction of PUFA compared with the other fatty acid families. Cooking of chicken thigh meat led to a reduction in FA content that affected all 3 families of fatty acid in a similar proportion. This reduction was 6.2% for SFA, 6.8% for MUFA, and 5.7% for PUFA as studied by Cortinas *et al.* (2004). However, Dawson *et al.* (1990) did not observe differences in fatty acid profile between raw and cooked chicken thighs (cooked at 80 to 90°C). Sainsbury (2009) reported that the saturated fatty acid (SFA) content didn’t differ significantly between the raw and cooked fat, but monounsaturated fatty acid (MUFA) and polyunsaturated fatty acid (PUFA) content decreased significantly during cooking. Omega 3 (n-3) and Omega 6 (n-6) fatty acids decreased significantly during cooking. The P:S ratio of the cooked fat (0.56) is lower than that of the raw fat (0.61). A higher P:S ratio is more advantageous to a person’s health as a high saturated fatty acids content is connected to a negative health image. According to van Heerden (2007), the cooked shoulder and loin cuts mainly contained less fatty acids than raw cuts while the cooked leg cut contained more of the C14:0, C16:0 and C20:0 saturated fatty acids than that of the raw cut.

### 2.3.2.3. Cholesterol

#### 2.3.2.3.1. Effect of breed on cholesterol content

Total cholesterol content of meat from Criollo Cordobes and Anglonubian kids ranged from 59.1mg/100g to 65.9 mg/100g muscle and was not affected by genotype and slaughter weight (Pena *et al.*, 2009). Whereas, Chizzolini *et al.* (1999) reported that total cholesterol in muscle varied between 61 and 63.5mg/100g.
2.3.2.3.2. Effect of muscle location on cholesterol content

No muscle differences were observed for total cholesterol in bovine muscles by Terrell et al. (1969). Significant and interesting difference, instead, have been reported in cholesterol content between muscle types by Chizzolini et al. (1999). Fernandez et al. (1995) reported that in pigs, *Longissimus lumborum* muscle (predominantly white) was found to have significantly lower content of cholesterol than *Semispinalis capitis* (predominantly red). In beef, although to a lower extent compared with pork, Browning et al. (1990) found that *Supraspinatus* and *Infraspinatus* muscles had higher cholesterol content than other muscles. Loin cut contained higher cholesterol than shoulder and leg cuts in South African mutton (Sainsbury, 2009). Cholesterol content of *Longissimus dorsi* and *Semimembranosus* muscle was 71.76 and 73.06 mg/100g in Jamunapari goats (Das and Rajkumar, 2010).

2.3.2.3.3. Effect of cooking on cholesterol content

Cooking causes a weight loss which is primarily due to removal of water. Calories and cholesterol per gram, therefore, normally increase on a wet tissue basis but the picture is obviously different on a dry matter one (Chizzolini et al., 1999). Cooked *Longissimus* muscle contained 26.8% higher cholesterol (wet weight basis) than the uncooked muscle of beef cattle and this is the result of an increase in concentration due to loss of moisture and some fat during cooking, not an actual increase in cholesterol content (Wheeler et al., 1987). However, according to Lewis et al. (1993) cholesterol values in meat do not change appreciably on cooking, since negligible amounts are lost from membranes.

According to van Heerden (2007), the cholesterol content for three cooked lamb cuts was higher, although not significantly, than the raw cuts, with the shoulder cut containing the highest cholesterol.
2.3.3. MEAT QUALITY

2.3.3.1. Effect of breed on meat quality

In terms of pH values in Longissimus dorsi and Semimembranosus muscles at 45 min and 24 h post-slaughter, the differences between genotype and sex groups were not statistically significant in case of Awassi and Turkish Merino × Awassi (F1) lambs. Additionally, in terms of drip loss and cooking loss, the differences between genotype and sex groups were not statistically significant (Celik and Yilmaz, 2010). Kadim et al. (2004) reported that there were significant differences in meat pH between the three goat breeds. The muscles from the Batina goat had higher ultimate pH than Dhofari goat, with the Jabal Akdhar goat being intermediate. Ekiz et al. (2009) reported that the effects of breed on mean pH levels at 45 min. and 24 h. post mortem and also on pH decline between these two pH measurements were not significant in case of Turkish Merino, Ramlic, Kivircik, chios and Imroz breed of lamb. Similar results were found by Martinez-Cerezo et al. (2005a) and Sanudo et al. (1997) in case of different lamb breeds. However, some other studies reported significance differences in ultimate meat pH among sheep genotypes (Hoffman et al., 2003; Hopkins and Fogarty, 1998).

Researchers have found that genotype significantly influenced (P < 0.05) the weight loss due to cooking, shearing force, colour (intensity of yellowness and luminescence), and the sensory attributes of flavour, odour, and raw colour of the goat meat but there were no significant (P > 0.05) differences in the WHC, pH and total lipid content within the same breed of goat. Silva et al (2011) found no significant (P<0.05) differences in terms of pH value among the different cut up parts of goat carcass which was due to the fact that all animals were subjected to the same period of pre-slaughter fasting (which determines the concentration of glycogen stores) and the same post-slaughter procedures.

Breeds of lamb did not have significant effect on water holding capacity (Ekiz et al., 2009 and Sanudo et al., 1997) and cooking loss (Ekiz et al., 2009 and Hoffman et al., 2003). But, several authors reported significant differences in cooking loss among sheep genotypes (Hopkins and Fogarty, 1998 and Sanudo et al., 1997). Breed differences in cooking yield have also been reported by Schonfeldt et al. (1993).
Lack of statistically significant differences were revealed among goats of three Bulgarian breeds with respect to pH, water holding capacity, colour, muscle fiber thickness and fatty acid composition of fat in *Longissimus dorsi* muscle (Stankov et al., 2002). There was no significant effect of breeds on water holding capacity as found by Das and Rajkumar (2010).

Meat from three different age groups (6-12 months, 12-18 months and above 18 months) of Black Bengal goat did not vary significantly in terms of moisture, protein, fat, ash, pH and WHC but differ significantly in fiber diameter and tenderness (Bhattacharyya et al., 2004).

There was some variation in the percentage loss on cooking between different goat genotypes and it ranged from 25-28.8%, which is within the normal range of goat meat (Dhanda et al., 2003a). Cooking loss differed (P<0.05) between genotypes and ranged from 23.7-26.4% in case of three Ethiopian goat breeds (Sebsibe, 2006). Similar results were found by Kadim et al. (2004) in Omani goat breeds. Bonvillani et al. (2010) reported that cooking losses ranged from 19.1 to 25.4%, which is within the normal range for goat meat.

### 2.3.3.2. Effect of muscle location on meat quality

The pH, water holding capacity, cooking loss, shear force value and organoleptic evaluation of *Longissimus dorsi* (LD) and *Semimembranosus* (SM) muscles of Barbari, Jamunapari and Marwari male goat kids were assessed by Das and Singh (2006) for comparative meat quality evaluation. The results showed that pH of the muscles were in the range of 5.67 to 5.86 while SM muscle had higher ultimate pH in all the three breeds compared to LD muscle. SM muscle showed comparatively higher water holding capacity and lower cooking loss though the difference was not significant. Hildrum et al. (2009) reported that the difference in ultimate pH_{58} between muscles was highly significant in case of Norwegian Red bulls.

According to Islam et al. (2010), the mean pH value of different cuts of goat carcass ranges from 5.65-5.69, didn’t differ significantly. They concluded that the age and different wholesale cuts have direct influence on quality of goat carcass. Dunne et al.
(2008) reported that there was a muscle x time interaction (P<0.001) for muscle pH. The pH of *M. Extensor capri radialis* (ECR) was higher (P<0.05) than that of *M. Longissimus dorsi* (LD) but the magnitude of the difference decreases as time post mortem increased. ECR muscle had higher cook loss than LD muscle.

Water holding capacity was higher for *Longissimus* (LT) than the *Infraspinatus* (IS) muscles from five contrasting groups of pasture-finished cattle as found by Purchas and Zou (2008).

Muscle fiber diameters were 38.9 µm and 29.8 µm in thigh muscle in case of Black Bengal goats selected for growth and randomly bred Black Bengal goats respectively. In neck, those values were 31 µm and 25.8 µm respectively (Amin et al., 2000).

Rhee et al. (2004) found that cooking loss of the steaks differed (P < 0.05) among muscles. Cooking loss was lowest (P < 0.05) for *Biceps femoris* (18.7%) and was followed by *Longissimus thoracis et lumborum* and *Infraspinatus* (20.7%); it was highest (P < 0.05) for *Semitendinosus* (27.4%) in steer carcasses.

Islam et al (2010) studied four different cuts of goat carcass, i.e. shoulder, rack, loin and leg and found no significant difference in terms of pH (5.65-5.69), the ranges of crude protein (CP) content (20.78-27.71%) differed significantly (p < 0.01) and leg portion contained higher CP than other portion, the fat and moisture content also differed significantly which ranged from 2.66-11.47% and 69.2-73.31% respectively. No significant differences were observed in terms of Ether Extract and Ca content in those cuts.

Cooking caused a rise in pH presumably due to the denaturation of proteins (Dzudie et al., 2000).

### 2.3.4. HEAVY METAL AND PESTICIDE RESIDUE:

Heavy metal pollution is becoming a serious health concern in recent years. Presence of heavy metals at toxic levels has been reported from India and other countries in livestock, especially in muscle and other tissues used as meat (Rajaganapathy et al., 2011).
Contamination with heavy metals is a serious threat because of their toxicity, bioaccumulation and biomagnifications in the food chain (Demirezen and Uruc, 2006). Rajaganapathy et al., (2008) studied the heavy metal level in beef sample in industrial area of Palakkad, Kerala, India.

The toxic heavy metals of great concern are lead, cadmium and mercury which are usually associated with harmful effects in men and animals (Rajaganapathy et al., 2011). Presence of substantiate levels of toxic metals like lead and cadmium in meat products have been recorded by González-Weller et al. (2006). Robinson (1994) reported lead content of 29 ppm in goat meat from Chennai city, India, which is at toxic level. A study carried out by John and Jeanne (1994) showed that levels of arsenic, cadmium, mercury and lead were detected in several tissues of goats; the results showed that the levels of the above metals were found to be very high and generally above the permissible level. Lead content in muscle samples from different animals as studied by Abou Donia (2008) were 0.048 mg/kg, 0.077 mg/kg and 0.106 mg/kg (in buffalo); 0.055 mg/kg, 0.079 mg/kg and 0.103 mg/kg (in cattle); 0.006 mg/kg, 0.052 mg/kg and 0.090 mg/kg (in sheep) and 0.009 mg/kg, 0.055 mg/kg and 0.098 mg/kg (in goat) in heavy traffic area, urban area and industrial area respectively. Cadmium levels were recorded in the range of 0.1 to 0.2 mg kg\(^{-1}\) by Coleman et al. (1992) in muscle of food animals. The maximum permissible limit (MPL) prescribed in Australia for cadmium in muscle of livestock and poultry is 0.2 ppm (Coleman et al., 1992). Mariam et al. (2004) found that the concentration of cadmium in the lean poultry meat (0.31 ppm) was lower than the 0.5 ppm, the permissible limit (FAO/WHO, 2000). They also found that in the lean meat of beef, mutton and poultry the lead concentration was observed to be higher than the permissible limit. In lean meat of mutton, the arsenic, cadmium, lead, copper and zinc content were 42.40 ± 4.95 ppm, 0.37 ± 0.06 ppm, 4.25 ± 0.54 ppm, 5.01 ± 2.46 ppm, 65.82 ± 6.29 ppm respectively (Mariam et al., 2004). Meat Food Products (Amendment) order (1993) prescribed that no meat food product shall contain more than 2.5 ppm lead and more than 1 ppm arsenic by weight.

Essential trace minerals like Zn, Cu and Mn are given special attention throughout the world due to their toxic effect in the body when their concentrations exceed limits of safe exposure (Reilly, 1991; Skurikhin, 1993). Maximum permissible limit of Zn and Cu
in meat foodstuffs is 50mg/kg and 20mg/kg respectively (Meat Food Products Order, 1973). As contaminants however no maximum permissible limit (MPL) has been fixed for Mn in vegetables and meat foodstuffs. Zn, Cu, and Mn concentrations were determined in the samples of vegetables and meat foodstuffs commonly found in Manipur, India by Singh and Taneja (2010). The concentrations of Zn, Cu, and Mn in case of meat foodstuffs ranged from 102.8 to 165.2 mg/kg of Zn, 1.2 to 5.8 mg/kg of Cu and 0.78 to 1.5 mg/kg of Mn. Cu and Mn concentrations in the meat foodstuffs were found to be below the safe limits whereas, the levels of Zn found in the meat were above the permissible limit established by regulatory organization. Taneja and Mandal (2007), reported levels of Zn as 79 to 174mg/kg in the meat foodstuffs found in and around Chandigarh, India. Furthermore, Mahaffey et al. (1975), reported that meats, fish and poultry contained an average 24.5 mg/kg of Zn. Coleman et al. (1992) and Jayasekara et al. (1992) reported that in fresh meat samples of various food animals level of Zn is below MPL (50 ppm). Whereas, Langlands et al. (1987) observed a zinc level upto 70 and 57 mg kg$^{-1}$ in muscle of cattle and sheep, respectively and Simakova et al. (1993) reported a zinc level upto 83.2 mg kg$^{-1}$ in beef and 5.4 mg kg$^{-1}$ in pork. Zinc level of 14.72 mg/100g has been reported in goat muscle, kidney and liver from Chennai, India, which is at toxic level (Ayyadurai and Krishnasamy, 1986). According to Lopez-Alonso et al. (2000), muscle is one of the important tissues for Zn accumulation and possesses Zn concentrations that were similar to those in the liver. High mean Zn concentration in rural areas was detected by Abou-Arab (2001) in goat muscle (39.6 Mg/kg). Meat and meat products showed the highest accumulation of zinc (Bordajandi et al., 2004).

The concentrations of iron (Fe), copper (Cu), zinc (Zn), nickel (Ni), manganese (Mn), cadmium (Cd), lead (Pb) and chromium (Cr) in chicken meat, chicken gizzard and turkey meat consumed in southern Nigeria were studied by Iwegbue et al. (2008). The order of the elements in the chicken meat, chicken gizzard and turkey meat was as followed: Fe>Zn>Ni>Cu>Cr>Pb>Cd>Mn. The concentration ranges of the elements were: 23.59–97.72 mg.kg$^{-1}$ Fe; 0.01–5.15 mg.kg$^{-1}$ Cu; 4.95–48.23 mg.kg$^{-1}$ Zn; 0.13–7.93 mg.kg$^{-1}$ Ni; 0.01–1.37 mg.kg$^{-1}$ Mn; 0.01–5.68 mg.kg$^{-1}$ Cd; 0.01–4.60 mg.kg$^{-1}$ Pb and 0.01–3.43 mg.kg$^{-1}$ Cr. The concentrations of iron, manganese, copper, zinc were below the permissible limits while those of cadmium, nickel, chromium and lead in some samples were at levels above the permissible limits. Although no MPL has been
prescribed by Meat Food Products Order (Meat Food Products Order, 1973) for chromium in food products, the MPL in mineral water has been specified as 0.05 mg L\(^{-1}\) by the (Codex Alimentarius Commission, 1994). Concentration of Cr (mg/kg FW) varied little amongst neck muscle, \textit{quadriceps femoris, triceps and trapezious} of Black Bengal bucks as revealed by Paul \textit{et al.} (2005). Khan \textit{et al.} (1995) reported that the concentrations of Cu, Fe, Mn and Zn in muscle were not significantly different between male and female goats; however, the concentrations of Fe and Zn in muscles were significantly different between young and old goats. Mn and protein contents had no significant difference among different pig breeds (p>0.05) as revealed by Guang-zhi \textit{et al.} (2008).

\textbf{Reported values of Cadmium, chromium, and Lead residues in goat meat:}

<table>
<thead>
<tr>
<th>Residues</th>
<th>Animal</th>
<th>Reported Level (mg/L)</th>
<th>Reference</th>
</tr>
</thead>
<tbody>
<tr>
<td>Cadmium</td>
<td>Goat</td>
<td>0.00032-0.00051</td>
<td>Khan et al (1995)</td>
</tr>
<tr>
<td></td>
<td></td>
<td>0.34-0.57</td>
<td>Swaileh et al (2001)</td>
</tr>
<tr>
<td>Chromium</td>
<td>Goat</td>
<td>0.00044-0.00362</td>
<td>Swaileh et al (2001)</td>
</tr>
<tr>
<td>Lead</td>
<td></td>
<td>0.00111</td>
<td>Khan et al (1995)</td>
</tr>
<tr>
<td></td>
<td></td>
<td>0.0002-0.0047</td>
<td>Swaileh et al (2001)</td>
</tr>
<tr>
<td></td>
<td></td>
<td>0.321</td>
<td>Abou Donia (2008)</td>
</tr>
</tbody>
</table>

The levels of heavy metals in the meat of beef, mutton, caprine and chicken were recorded by Akan \textit{et al.} (2010). The levels of heavy metals in the meat of beef, mutton, caprine and chicken ranged from 0.15 to 0.43 \(\mu\)g/g (chromium); 0.04 to 0.10 \(\mu\)g/g (Pb); 0.01 to 0.24 \(\mu\)g/g (Cu); 0.98 to 2.87 \(\mu\)g/g (Fe); 0.01 to 0.22 \(\mu\)g/g (Ni); 0.06 to 0.32 \(\mu\)g/g (Co); 0.45 to 3.20 \(\mu\)g/g (Mn); 0.070 to 0.29 \(\mu\)g/g (Cd); 0.01 to 0.13 \(\mu\)g/g (As) and 0.10 to 2.04 \(\mu\)g/g (Zn).

Status of arsenic and mercury in muscle samples from goat in two different zones of Haryana was studied by Roy \textit{et al.} (2011). They reported mercury content of goat muscle as 1.61 ppb and 1.50 ppb respectively in the two selected zones, whereas the arsenic content of goat muscle was 2.84 ppb and 2.18 ppb respectively.
García-Vaquero et al. (2011) demonstrated that in cattle, non-essential and essential trace element concentrations significantly varied between muscles. The most active and less fat content muscles showed in general the highest essential and the lowest non-essential trace element accumulation in comparison with the other muscles analyzed.

Abd El-Salam et al (2013) detected the presence of Pb, Cd, Co, Cu, Zn and Fe in the goat meat with an average value of 2.15 ± 0.016, 0.375, 1.88 ± 0.001, 4.088 ± 0.008, 26.41 ± 0.11 and 10.75 ± 0.02 respectively.

Ahmad et al (2010) analysed the organochlorine pesticide residues in egg, chicken, lamb and beef meat and found (in mg/kg concentration) DDT, Dieldrin, \( \alpha \)-Endosulfan, \( \alpha \)-HCH and Hexachlorobenzene concentration of 104.6±8.8, 93.9±2.5, 93.3±2.9, 91.3±2.4 and 91.3±2.7 respectively in chicken meat.

Sallam and Morshedy (2008) showed that heat treatment of meat (boiling for 1.5 h) produced overall reductions of 40.4%, 55.0%, 32.4%, 33.5%, 29.2% and 38.2% in DDTs, lindane, dieldrin, aldrin, endrin and HCB contents, respectively. This could be attributed to the volatility of these compounds and to the elimination with the fat rendering induced by high temperatures.

Wani et al (2000) reported that Cooking caused a reduction in DDT, HCH and their metabolites/isomers with concomittent increase in the level of DDD residue in meat, liver, adipose tisse and kidney samples of goat . Broiling was the most effective method for reducing pesticide residues in meat while boiling, pressure cooking and microwave cooking were equally effective.