

*Review Article*

## **REVIEW ON CALPAIN MEDIATED POST-MORTEM AGEING ON THE QUALITY OF PRE-COOKED BREAST FILLETS FROM BREEDER BROILERS**

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**Abstract:** Chicken breast fillet is a versatile meat product in India, and has wider acceptability throughout the world. However, there is very little information on the effect of calpain mediated post-mortem ageing on the quality of pre-cooked breast fillets from breeder broilers. So, efforts were made to best utilize the breast fillets from breeder broilers by applying different post-mortem aging methods, optimization of marinade and adopting variety of cooking techniques. The storability study and cost of economics for pilot scale processing of breast fillets were also carried out to evaluate the feasibility and commercial viability of products with a view to transferring the technology to small entrepreneurs.

**Keywords:** Chicken breast fillet, calpain, post-mortem ageing, cooking techniques.

### **INTRODUCTION**

In the current scenario as per the changing demand of the society it is required to develop new meat products or upgrading the existing ones. Today, the meat from broiler breeders is usually considered a by-product of the poultry industry and usually fetches lower price as compared to market weight broilers (Navid *et al.*, 2011). Poultry meat from spent animals is a good source of nutrients such as proteins and omega-3 fatty acids (Chueachuaycho *et al.*, 2011). It also holds an important place in Indian culinary practices, so we cannot afford to underutilize such a valuable source of animal protein keeping in mind malnutrition of large section of population in the country (Mendiratta *et al.*, 2012), further meat from large size carcass like broiler breeders or spent chicken is more suitable for processing of value added meat products (Kondaiah, 2010).

### **SKELETAL MUSCLE STRUCTURE**

The skeletal muscle consists mainly of long, thin muscle fibres, each of which is a single multi-nucleated cell. Nearly 60 % of the volume of each fibre cell consists of myofibrils. These are long, cylindrical cytoskeletal structures that transverse the entire length of the . The primary function of skeletal muscle is to generate contractile forces that are expressed through the limbs as voluntary movement. Muscles utilise ATP as the major source of energy

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in order to perform muscular functions and to maintain functional integrity. Meat from spent layers is dry, tough and strong due to its high collagen contents and cross linkages (Awosanya and Faseyi, 2001). The amount of intramuscular connective tissue, the length of sarcomere, and the activity of endogenous proteolytic enzymes influenced the toughness of meat (Kemp and Parr, 2012). Changes in myofibrillar proteins are responsible for the actomyosin toughness that in connective tissue cause the background toughness (Chen *et al.*, 2006). Naveena *et al.*, (2011) reported that myofibrillar toughness is affected by the development of rigor-mortis and tenderization caused by the enzymatic breakdown of the contractile proteins. Devine *et al.* (2006) stated that low ultimate pH was necessary to obtain optimum tenderness.

### **POST-MORTEM MUSCLE METABOLISM**

After slaughter, aerobic metabolism declines with the decreasing oxygen supply, instead, anaerobic metabolism accounts for most glycolysis, and a pH value that falls to 5.4 - 5.8. In addition, many investigations have shown a series of intracellular environmental changes occurred during the process that produces a high ionic strength and muscle cells that are unable to keep the reducing conditions (Huff- Lonergan *et al.*, 2010). The decline of temperature and pH parallels the development of rigor, and is partially associated with it. Consequently, these changes have an effect on the rate of tenderization and occasionally on water holding capacity (Simmons *et al.*, 2008). After slaughter, muscle goes rapidly into rigor mortis and becomes tough and tenderness declines. Subsequently, as the aging process occurs there is an improvement in tenderness (Grobbel *et al.*, 2008).

Development of tenderness in meat during post-mortem is caused by proteolytic activity where alteration is made to the muscle structural and associated proteins. Proteolysis in meat is initiated by a protease systems in which vital cytoskeletal proteins such as desmin, titin and those associated with structures maintaining the myofibril interaction with the sarcolemma (the costameres) are cleaved (Kemp *et al.*, 2010). The basic criteria defining a protease system which could be involved in this tenderization process is that it must be endogenous to skeletal muscle cells, able to induce post-mortem changes *in-vitro* under the optimal conditions similar to those seen *in-situ* and have access to the myofibril (Koohmaraie, 1988). A number of enzyme systems have been described as being associated with the proteolytic activity. These include the calpain system, cathepsin lysosomal system, caspase system and finally the ATP-dependent proteosome system (Kemp *et al.*, 2010).

The role of each of these proteolytic systems in muscle post-mortem proteolysis has been the subject of a much research and associated debate. Essentially, there are three models, which have been postulated as the proteolytic processes, which are responsible for meat tenderization. The first is only focused on the calpains as the main protease responsible in meat tenderization; the second suggests cathepsin and calpain are both involved in the process and the third suggesting a multi-enzymatic process which includes proteasomes, caspases, calpains, and cathepsins during post-mortem (Ouali *et al.*, 2006). The majority of studies have agreed that the calpain system plays a major role in post-mortem tenderization.

### **ENZYMES IN TENDERIZATION (THE CALPAIN SYSTEM)**

Calpains are a large family of intracellular cysteine proteases. In skeletal muscle, the calpain system consists of three proteases, ubiquitously expressed isoforms  $\mu$ -calpain,  $m$ -calpain, and tissue specific form calpain 3 (p94). The ubiquitously expressed  $\mu$ - and  $m$ -calpain are calcium-activated proteases, requiring micro- and millimolar concentrations of  $\text{Ca}^{2+}$  for activation, respectively. Associated with the calpain proteolytic enzyme family is the calpain-specific endogenous inhibitor, calpastatin. Although various observations indicate a central role of calpains in post-mortem proteolysis they do not indicate which of the calpain proteolytic isoforms is responsible for the post-mortem degradation. In order to directly examine the effect on p94 muscle function p94 knockout mice were used to examine the effects of the absence of calpain 3 on post-mortem muscle (Geesink *et al.*, 2005). But calpains can cleave limited myofibrillar proteins such as titin, desmin and vinculin, and contribute to the improvement of tenderness, whereas, high levels of calpastatin are related to decreased proteolysis and increased meat toughness (Kemp *et al.*, 2010)

Myofibrils incubated with calpains have produced similar degradation patterns to those observed in post-mortem muscle, with calpains degrading key myofibrillar proteins including nebulin, titin, troponin-T and desmin (Kemp *et al.*, 2010). Originally, it has been difficult to determine which isoform is primarily involved in post-mortem proteolysis, because both  $\mu$ - and  $m$ - calpain can cleave the same myofibrillar proteins. Several experimental investigations showed that the activity of  $\mu$ -calpain changed with the post-mortem proteolysis of key myofibrillar proteins rather than  $m$ -calpain (Riley *et al.*, 2003). Additionally, the  $\text{Ca}^{2+}$  concentrations that exist in muscle post-mortem are less than that required of  $m$ -calpain for activation. Recently the evidence for a significant role of  $\mu$  -calpain in post-mortem proteolysis has further been strengthened from observations made in  $\mu$ -calpain knockout mice (Geesink *et al.*, 2006). Therefore, it is clear that  $\mu$ - calpain plays the most significant role in

post-mortem muscle proteolysis and meat tenderization (Kemp *et al.*, 2010), while *m*-calpain plays a minor role in meat tenderization (Camou *et al.*, 2007).

Calpastatin another enzyme of calpain system inhibits both  $\mu$ - and *m*-calpain activity and this process requires calcium concentrations that are reported to be close to or below those that are required to activate calpain. However, calpastatin is itself susceptible to proteolysis but the resulting fragments retain inhibitory activity (Hanna *et al.*, 2008). Calpastatin is an unstructured protein but when it binds calpain it adopts a structure, which allows inhibition to take place. Calpastatin contains four inhibitory domains, each of which can inhibit calpain activity. However, Moldoveanu *et al.* (2008) reported that that the inhibitory domains are not equivalent at inhibiting calpains, which might, as suggested by Mellgren (2008), be the mechanism by which calpains degrade calpastatin via the cleavage of the weaker inhibitory domains, creating specific peptide fragments that retain inhibitory activity. However, Moldoveanu *et al.* (2008) reported that that the inhibitory domains are not equivalent at inhibiting calpains, which might, as suggested by Mellgren (2008), be the mechanism by which calpains degrade calpastatin via the cleavage of the weaker inhibitory domains, creating specific peptide fragments that retain inhibitory activity.

## **PHYSICO-CHEMICAL CHARACTERISTICS**

### **i) pH**

The pH of muscle/meat is a measurement of acidity. It is considered as one of the most important meat quality parameters. The pH of meat after slaughter is affected primarily by the post-mortem conversion of muscle glycogen to lactic acid that accumulates in the muscle (Lawrie, 1998). Changes in muscle pH also directly affect colour and WHC of meat proteins by effecting the protein structure and subsequent hydration properties (Petracci *et al.*, 2001).

Laack *et al.* (2000) reported that broiler breast muscle had a pH of 5.9 and can uptake 44.3% marinade. The pH of breast meat was found to be lower than leg meat at all the ages and pH of breast and leg meat increased with age but was highest at 8 weeks of age (Hazarika, 2004). Vaithyanathan *et al.* (2008) reported pH value for breast meat of spent hen were 5.73, 5.58, 5.66, 5.44 and 5.3 when kept in refrigeration ( $4 \pm 1^\circ\text{C}$ ) for 0, 7, 14, 21 and 28 days respectively.

Kumar *et al.* (2011) found 6.13 and 5.80 pH value for dark meat and white meat of broiler breeders. Kumar *et al.* (2015) reported pH value 6.43, 6.33, 6.22 and 6.21 when meat spread developed from spent hens and stored at 0, 7, 14 and 21 days at refrigeration temperature.

### **ii) Water holding capacity (WHC)**

Water-holding capacity of meat is defined as the ability of the post-mortem muscle (meat) to retain water even though external pressures (e.g. gravity, heating) are applied to it. Bhardwaj *et al.* (1995) studied the keeping quality of broiler chicken meat and its influence on cooking loss and reported that water holding capacity decreased significantly with the advancement of age from 4 to 8 wks. Breast meat showed significantly higher WHC than high and drumstick meat. Mahapatra *et al.* (1989) compared the meat quality from farm bred (CARI) and native chicken and reported that WHC decreased gradually with increasing age. Breast muscle exhibited more WHC compared to leg muscle. Significant differences were observed between the WHC of breast and leg meat of different weeks broilers (Hazarika, 2004).

Higher water holding capacity of 63.64 and 62.71% was found in breast and thigh meat of broiler chicken respectively (Omojola and Adeshinwa, 2007). Kumar *et al.* (2011) reported water-holding capacity 15.71 % for broiler spent dark meat and 10.71 % for broiler-spent white meat. Mendiratta *et al.* (2012) reported that WHC decreased significantly with increase in ageing time after slaughter.

### **iii) Proximate composition**

Mahapatra *et al.* (1984) reported higher moisture % in the muscle of male (73.86%) than female (72.75%) broilers, whereas fat % was higher in female (4.51) compare to male (4.05) and also the protein % recorded to be more in female (19.72%) compared to 19.61% in male broilers.

Pandey and Sharma (1989) reported that female broilers of 8 wks of age exhibited equal protein percent of 19.1% but increased moisture and decreased fat % than male birds. Moisture and fat content were noted to be 74.0 and 3.2% in females whereas 73.7 and 3.3% in male birds respectively.

Hazarika (2004) studied on value added poultry products from heavy weight broilers and found moisture % decreased and protein and fat % increased for both breast and leg meat as the age and live weight increased from 7 to 9 weeks and low to heavy weight respectively in broilers.

Ilayabharathi *et al.* (2012) reported 57.1, 22.04 and 12.82% moisture, protein and fat for broiler meat sausage and 56.64, 22.04 and 13.76 % moisture, protein and fat for spent hen meat sausage, prepared from breast and leg meat.

Kumar *et al.* (2015) reported ready-to-eat meat spread developed from spent hens contained 58.75 moisture, 9.12 crude proteins and 11.19 % ether extract, and 2.35 total ash.

**iv) Warner-Bratzler shear force value (WBSFV)**

Shear force value is defined as the force needed to shear the muscles. Toughness or tenderness of muscle can be known by this value. Mahapatra *et al.* (1989) reported lower shear force values for breast muscle than leg muscle. In native chicken the Warner-Bratzler shear force values were 4.3 and 4.7 kg for breast and leg muscle respectively.

Poole *et al.* (1999) reported WBSFV of broiler breast fillets were 0.61, 0.76, 0.85 and 0.83 kg/cm<sup>2</sup> respectively, processed at 5, 6, 7 and 8 wks.

Hazarika (2004) studied on value added poultry products from heavy weight broilers and found shear force value increased for breast and leg meat with increasing age and live weight. Vaithyanathan *et al.* (2008) reported shear force value for spent hen breast meat when kept in refrigeration ( $4 \pm 1^\circ\text{C}$ ) for 0, 7, 14, 21 and 28 days were 3.81, 3.38, 2.93, 2.72 and 2.31kg respectively. Ilayabharathi *et al.* (2012) reported shear force values of broiler meat sausage 0.31 and spent chicken meat sausage 0.42 kg/cm<sup>2</sup>.

**v) Cooking yield**

Cooking yield is determined simply by weighing the meat product before and after cooking and is expressed as percentage cooking yield. Keshri *et al.* (1986) reported more cooking yield % of breast compared to thigh meat in white leghorn chicken of 20 months old. Bhardwaj *et al.* (1995) reported that cooking losses declined significantly with the advancement of age.

Pragati *et al.* (2006) reported cooking yields of microwave cooked breast fillets (MWBF), chicken tenders (MWCT) and grilled breast fillets and tenders increased with increase in live weights of the birds. Moisture, protein and fat content of the products increased gradually with the increasing live weight.

Kumar *et al.* (2011) reported 32.26 % cooking loss in broiler spent hen dark meat and 26.57 % in broiler spent hen white meat.

Ilayabharathi *et al.* (2012) reported cooking yield 93.10% for broiler meat sausage and 90.92% for spent chicken meat sausage, prepared from breast and leg meat.

**vi) 2-thiobarbituric acid reacting substances (TBARS) value**

The determination of 2-thiobarbituric acid reacting substances (TBARS) is a popular method for measuring oxidative deterioration of meat. Vaithyanathan *et al.* (2008) reported TBARS value for spent hen breast meat when stored at refrigeration temperature ( $4 \pm 1^\circ\text{C}$ ) at 0, 7, 14, 21 and 28 days, the TBARS values were 0.55, 1.32, 1.89, 1.57 and 1.92 mg of malonaldehyde/kg of muscle respectively. The TBARS value followed a significant

increasing trend from day 0 to 14 in treatment samples as well as control chicken meat balls (Bhat *et al.*, 2013). The increase in TBARS values on storage might be attributed to oxygen permeability of packaging material that led to lipid oxidation. Modi *et al.* (2009) who also found a similar increase in TBARS values upon storage of different meat products. The increase in TBA value during the storage period could be due to oxidative rancidity were also reported by many researchers (Biswas *et al.*, 2011). Kumar *et al.* (2015) reported 0.157, 0.232, 0.313 and 0.374 mg malondialdehyde/kg of meat sample when it was stored at 0, 7, 14 and 21 days at refrigeration temperature.

#### **vii) Peroxide value**

The oxidative status of meat can be assessed in the primary oxidation phase, by determination of peroxide value and free fatty acid content. Ramzija *et al.* (2010) found average peroxide values in 42 days old standard fattening chicken 7.77 meq/kg in breast muscle and 9.07 meq/kg in muscle. Kangaraju and Subramanian (2012) reported the mean peroxide value of freshly prepared pickle from spent duck meat was 57 meq/kg of sample. They also reported peroxide value of 47, 39 59, 65, 97, 44 and 46 meq/kg when meat pickle stored at 0, 15, 30, 45, 60, 75 and 90 days, respectively.

Singh *et al.* (2014) reported that throughout the storage period the peroxide value was significantly higher in control than natural preservative treated samples. Within the treated batches PV did not vary significantly.

Kripriyalini (2015) found that the peroxide value (PV) was lowest at 0 hrs and there were significant differences amongst the different age and sex of turkey breast and thigh samples.

Mishra *et al.* (2015) reported increasing trend of peroxide values for control and treated samples when extended dehydrated chicken meat rings were aerobically packaged and stored at ambient temperature from 0 to 45 days of storage.

#### **viii) Free fatty acid contents (FFA)**

Free fatty acid (FFA) content in meat determines the fat status and quality of the muscle foods and expressed as percent of oleic acid. Modi *et al.* (2004) reported FFA value in freshly prepared products 3.6 and 3.2% and found these values gradually increased during 6 months of frozen storage to 3.9 and 3.7 for fresh and smoked meat nuggets, respectively.

Rajan *et al.* (2014) prepared Chettinad chicken using boneless meat derived from spent hen and boiler breeder, the product was stored at ambient temperature ( $35\pm 2$  °C) up to 180 days; they found that free fatty acid decreased significantly during storage in the Chettinad chicken.

Increase of FFA contents in retort processed black calm meat was also observed by Bindu *et al.* (2004) during 12 months storage period.

Singh *et al.* (2014) reported on all the storage days FFA was significantly higher in control as compared to clove powder, ginger paste and garlic paste treated chicken meat emulsions. Das *et al.* (2011) reported increasing trend of FFA during refrigeration storage of raw ground meat for 9 days. Other workers also suggested similar trends in FFA of chicken meat products (Biswas *et al.*, 2012) and goat meat products (Das *et al.*, 2008) during 9 days of refrigeration storage.

Kripriyalini (2015) reported that within few hours of onset of ageing process, formation of FFA convene but all they vary marginally, and even after the ageing process is over FFA contents did not differ significantly amongst various samples and also ageing times. However, gradual increasing trends of FFA contents were observed with the increase of ageing time. It was reported that increased levels of FFA had no toxicological effects and products of hydrolysis of fats/oils have no adverse effect on the nutritional quality of foods (Fritsch, 1981). So FFA determination alone did not provide guide for acceptability of the meats, but support as suitable quality indicator for oxidative changes of fat.

Mishra *et al.* (2015) during his study on storage stability of aerobically packaged extended dehydrated chicken meat rings at ambient temperature reported progressive decrease in flavor scores and this could be correlated to an increase in TBARS number and free fatty acids in the meat products under aerobic conditions.

#### **ix) Protein extractability**

Protein solubility, or extractability, is a functional property used to classify muscle proteins and a physicochemical, trait often used as an indicator or precursor for other functional properties. Naveena (1999) reported total soluble protein values (gm protein extracted / 100 gm total muscle protein) of control and treated samples (3% ginger extract treatment) at pre and post-chill stages and found values of post-chill treated samples were significantly higher than pre-chill control. The values for myofibrillar protein for control and 3% ginger treated samples at pre- and post-chill stages did not differ significantly; the values for water soluble proteins for control and treated samples at pre-post chill stages differ significantly.

Kumar *et al.* (2011) reported extractable proteins of dark meat and white meat of Black and Beltsville white turkey did not differ significantly ( $P > 0.05$ ). The extractable proteins of dark meat of broiler-spent hens were significantly lower ( $P < 0.01$ ) than dark and white meat of Black turkey and Beltsville white turkey.

Naveena and Mendiratta (2001) reported higher extractability of protein in post-chilled chicken cuts (after 24 h of ageing) than pre-chill cuts.

Yalcin *et al.* (2014) reported that breeder age had no effect on initial sarcoplasmic protein solubility while total initial protein solubility was higher for meat from 28 wk breeders than from 48 wk breeders. Both sarcoplasmic and total protein solubility increased with slaughter weight.

Kim *et al.* (2015) observed the highest protein solubility for the pre-rigor chicken breast muscle salted with 4%. However, there was no significant difference in the protein solubility between chicken breast muscles salted with 3% and 4% NaCl ( $p > 0.05$ ).

#### **x) Myofibrillar Fragmentation Index (MFI)**

MFI value is an important factor determining meat tenderness, along with sarcomere length, ionic strength, and animal species (Koochmaraie, 1994). Obanor *et al.* (2005) reported that the meat was boned out at 3 h post slaughter showed significantly less proteolysis compared with that left on the carcass for the first 24 h as measured by MFI at 24 h postmortem. At 7 day postmortem the MFI values were still lower in the hot-boned breast meat, but the differences was not significant.

Kang *et al.* (2012) studied the effect of pineapple and papain on spent hen breast meat tenderization. The samples treated with papain and pineapple had significantly higher myofibrillar fragmentation indices than the other samples. Zarasvand *et al.* (2012) reported MFI significantly increased in ostrich meat and beef from one to seven days post-mortem at 4 °C. Kim *et al.* (2015) reported that pre-rigor chicken breast muscle salted with 2% NaCl showed lower MFI value than post-rigor chicken breast muscle salted with 2% NaCl.

#### **xi) Titrable acidity (TA)**

A possible reason for the increase in acidity as a result of irradiation and storage might be related to the participation of free fatty acids in the process of lipid peroxidation. Gecgel (2013) reported that the total acidity contents of meatballs displayed a dose dependent increase upon irradiation, he also found similar results during the storage period, total acidity values of control and irradiated meatball samples increased (0.60%). Previous studies have shown that significant differences in total acidity were observed as a result of both irradiation and storage (Sweetie *et al.*, 2006) However, Bakalivanova *et al.* (2009) founds no significant change in acidity following both gamma irradiation and during storage in salami and camel meat respectively.

### **xii) Casein Zymography**

Casein zymography specifically determines the activities of the calcium-dependent proteases, without prior purification steps that could alter their activity. It can also be used to analyze simultaneously a large number of samples and is particularly suited to comparative studies. The ratio of  $\mu$ -calpain to  $\mu/m$ -calpain was close to 1:10 and was unchanged 5 min after slaughter compared with the standard reference muscle and then decreased greatly, because  $m$ -calpain is very stable and had diminished little by 24 h post-mortem,  $\mu$ -calpain had strongly decreased by 6 h post-mortem (Lee *et al.*, 2007). Lee *et al.* (2008) reported that the activities of the different calpain isoforms in chicken pectoralis superficialis muscle changed after slaughter.

Kripriyalini (2015) reported that in turkey breast muscle and blood samples both  $\mu$ - and  $m$ -calpains appeared as single band on casein gel, but in case of thigh muscle,  $m$ -calpain appeared as single band while  $\mu$ -calpain was totally absent. The absence of clear band of  $\mu$ -calpain in casein gel indicated that it might be present in very low concentration i. e., below the threshold limits, which is not sufficient to lyse the casein.

### **xiii) SDS-PAGE analysis**

As calpastatin remain undetectable in casein gel due to lack of proteolytic domain, but their identification is important to assess inhibition activity of these enzymes to calpains. For identification of calpains and calpastatins in different purified fractions, SDS-PAGE is performed.

Naveena and Mendiratta (2001) reported the electrophoretic pattern of control and treated samples after 24 h treatment indicate that there was an increased proteolysis of muscle proteins in ginger extract treated samples, as shown by reduction in the number of protein bands. There was also a drastic reduction in the number of bands in the samples treated at post- chill stage compared with pre-chill samples.

The degradation of myofibrillar proteins takes place in spent-hen breast meat according to electrophoresis, Myosin degradation only occurred by myofibril disruption when the meat was treated with papain (Kang *et al.*, 2012). Kripriyalini (2015) reported that the  $\mu$ -calpain concentration was significantly higher at 0 hr in breast muscle and that was decreased with the increase in storage time.

## MICROBIOLOGICAL QUALITY

USDA recommended minimum internal end point temperature of cooking meat products to be 71.1°C which killed most of vegetative cells of bacteria, rickettsia, protozoa and fungi and inactivated viruses and enzymes present in food (Frazier, 1971).

Storage of products increases the microbial count and therefore, lowers the shelf-life (Rybka *et al.*, 2001). Nath *et al.* (1995) reported that the chicken patties stored under refrigeration showed a linear increase in total plate count, but a declining trend was observed in frozen storage condition.

Ilayabharathi *et al.* (2012) conducted microbial studies for shelf-life of spent chicken sausage and revealed a linear increase in the counts from 3rd day of storage onwards at chilling temperature. Sausages stored at freezing temperature recorded significantly lower total plate count, total plate psychophilic count, yeast and mould counts over chilling temperature.

Bhat *et al.* (2013) reported total plate count followed a significantly increasing trend from day 0 to 14 in treatment samples as well as in control, Psychophilic count followed a significantly increasing trend from day 7 to 14 in products containing skin as well as in control. Kumar *et al.* (2015) reported coliform count was nil when meat spread was stored at refrigeration temperature for 0, 7, 14 and 21 days, but psychophilic count was nil on 0 days and 1.64, 2.39, 3.45 log<sub>10</sub> cfu/g on 7, 14 and 21 days refrigeration respectively.

### **Effect of marination on meat products**

Marination is a traditional method widely used to improve meat quality before thermal processing. The advantages of marination are that it increases product yield, reduces water loss during cooking (Alvarado and McKee, 2007), and improves the tenderness of meat. Two of the most common ingredients in marinating solutions are sodium chloride and some type of phosphate (Barbut *et al.*, 1989). Both of these can help to increase water-holding capacity (WHC) due to an increase in electrostatic repulsion of myofibrillar proteins (Rust, 1987); this enlarges the space between actin and myosin filaments, allowing more water to be retained in the muscle (Lawrie, 1991).

Sodium bicarbonate is also an effective curing ingredient, it has a high potential to reduce drip loss and shear force and improves the yield of cooked meat (Bertram *et al.*, 2008). Komoltri and Pakdeechanuan (2012) during his result concluded that marinating chicken meat before processing into golek chicken influenced the texture and cooking yield of the product.

### **Effect of cooking time-temperature and cooking methods on meat products**

Meat and meat-based products are cooked before being eaten. Cooking step is critical for destroying food borne pathogens, assuring microbial safety and achieving meat quality. Cooking also has an important effect on the nutritional properties and same time on its possible toxicity (Kondjoyan *et al.*, 2014) with cooking meat becomes edible and more digestible (Białobrzewski *et al.*, 2010). Generally, consumer chooses a cooking method that produces high-quality meat products having favourable texture and taste (King and Whyte, 2006). Eating quality of meat is mainly affected by applied cooking method.

Aaslyng, *et al.* (2007) reported that cooking procedure (heating time or heating temperature) and heating method affects sensory characteristics of pork. High cooking temperatures and high cooking losses reduce juiciness of beef (Toscas *et al.*, 1999). Singh *et al.* (2015) reported significantly ( $P < 0.05$ ) lower moisture percent for hot air oven cooking than other cooking methods (deep fat fry, air fry and hot air oven plus shallow frying). Similar findings have been reported by Verma *et al.* (2013).

The effect of additives and microwave cooking on quality of spent hen chicken meat patties was studied by Sharma *et al.* (2005) and that microwave unpacked cooked chicken meat patties had lower moisture, less juiciness and harder texture than LDPE packed oven cooked patties. Singh *et al.* (2012) reported cooking parameters such as cooking yield and cooking losses showed non-significant differences among broiler chicken meat chat prepared by roasting, microwave and frying methods except in fat contents. Nisar *et al.* (2010) reported highest cooking yield in microwave cooking than pressure cooking and lastly in hot air oven cooking both in 15% added fat and 5% added fat groups of buffalo meat patties.

### **SENSORY EVALUATION**

Sensory evaluation of food has been defined as a scientific method used to evoke, measure, analyze and interpret responses to products as perceived through the senses of sight, touch, smell, taste, and hearing (Lawless and Heymann, 1998). Sensory analysis provides a better understanding of consumer perception of food products (Matulis *et al.*, 1994). The development of new food products often employs sensory evaluation techniques to determine the acceptability of food (Barbut, 2002).

Products prepared from heavy weight broiler group were found to be superior in relation to sensory characteristics compared to the low and medium group (Pragati *et al.*, 2006). Sensory panel analysis revealed a significant difference in the attributes studied on 6th day of storage at chilling temperature both in broiler and spent hen meat sausages; at freezing temperature

significant changes were noticed by the panelist at 9 days of storage (Ilayabharathi *et al.*, 2012). The decrease in the overall acceptability scores to the restructured chicken meat blocks was reported by Talukder *et al.*, (2013).

In the study of Nisar *et al.* (2010), the sensory panelists had awarded significantly ( $p < 0.05$ ) higher texture scores to patties cooked in hot air oven than buffalo patties cooked in microwave oven and pressure cooking for both the groups F1 (15% added fat) and F2 (5% added fat). Sharma *et al.* (2005) also reported that chicken meat patties cooked by microwave oven were hard and have low juiciness and other organoleptic characteristics than convection oven cooked patties. Pawar *et al.* (2002) reported that the aroma, flavour and palatability of hot air oven cooked products were found to be better and more acceptable as compared to microwave oven cooked products.

Singh *et al.* (2012) concluded that overall sensory scores on colour and appearance, flavor, texture and mouth coating of chat prepared by roasting were very similar to that of frying but these scores were significantly ( $p < 0.05$ ) different in chat scores obtained on microwave cooking. Among all three cooking, broiler chicken meat chat prepared by roasting had the highest scores followed by frying and microwave cooking. Nisar *et al.* (2010) found the hot air oven cooked patties were rated the best in terms of overall acceptability of the product, he also concluded that the overall acceptability score of the patties cooked by hot air oven were significantly higher than microwave oven cooked patties.

## CONCLUSION

Micro- $(\mu)$  calpain mediated post-mortem ageing was substantially improved raw and processed fillets quality during holding at room and refrigeration temperatures. Post-mortem ageing periods for both types of breast fillets (room and refrigeration temperature stored) were standardized at 4 and 24 h, respectively. Microwave (MW) grilling was selected best cooking method for development of good quality breast fillets with better sensory acceptability. Post-mortem ageing of breast fillets had ample influence on improving product quality in terms of decreased in Warner-Bratzler shear force value (WBSFV), but increased moisture retention and sensory acceptability of finished products. Precooked breast fillets can be well stored up to 15 days at refrigeration temperature under aerobic packaging condition without appreciably affecting product quality and sensory acceptability. Economics of production of broiler breast fillets from spent fowl indicated its viability in favour of small scale entrepreneurs.

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