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TENDERIZATION, A METHOD TO OPTIMIZE THE MEAT SENSORY QUALITY

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Abstract: *The meat industry is in a continual search for methods to improve meat tenderness. Artificial meat tenderness is of interest especially for beef meat due to the inconsistency among bovine muscles. Tenderizing of beef meat is carried out by several methods: dry-aging, mechanical, thermal, chemical and enzymatic methods, treatments with ultrasound or high pressure. Reviews of the studied methods are discussed. Among these, the better results were observed when the vegetative enzymes were applied.*

Key words: *meat, tenderizing, enzyme.*

1. Introduction

The quality of meat products is a major problem that currently concern both meat industry and consumers. Of the six meat palatability factors: tenderness, juiciness, flavor, aroma, color, texture, tenderness is generally considered the most important palatability factor by the consumer.

As consumers, some people determine meat tenderness by how easily the teeth sink into the piece of steak upon first bite and others based upon the number of chews before the piece is swallowed. Consequently, the meat industry is in a continual search for methods that might improve the tenderness of meat.

The scientific research aimed to a better knowledge of the phenomena and transformations that occur during preservation and meat processing in order to choose the optimum conditions for obtaining higher quality products.

Usually, natural aging process is a long process and for safety reasons the artificial tenderness is recommended in meat industry.

Artificial meat tenderness is of interest especially for beef meat due to the inconsistency among bovine muscles. Beef palatability is affected by many factors and tenderness is cited as one of the most important.

Generally, the two primary structural features of muscle that influence tenderness are integrity of the myofibrils and the connective tissue contribution.

Have been identified six characteristics of perceived tenderness. Three characteristics relate to the myofibrillar portion, two relate to product adhesion, and the remaining one relates to connective

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tissue components. Myofibrillar proteins are located intracellularly while connective tissue proteins are located extracellularly. This difference in distribution of key proteins within the muscle increases the challenge of improving tenderness. Stated simply, some muscles may lack palatability because of myofibrillar proteins while others may lack palatability because of the connective tissue proteins. A plausible tenderization strategy should target one or both of the main structural constraints to be successful [4].

2. Meat Composition and Structure. Post-mortem Changes

The muscle consists of 75% water, 20% protein, 3% fat and 2% soluble non-protein substances. The proteins can be divided into three groups: myofibrillar, sarcoplasmic and connective tissue proteins. The myofibrillar proteins constitute between 50 and 55% of the total protein content, while the sarcoplasmic proteins account for approximately 30–34%. The remaining 10–15% of the proteins is the connective tissue proteins.

After death, the muscle fibers contract as the lactic acid content increases in the muscle.

This is known as rigor mortis and this occurrence causes muscle to become less tender especially in young cattle. Rigor is complete after about 48 hours post-mortem. The lactic acid is produced after death from glucose which is stored in muscle.

This is called “post-mortem glycolysis” and occurs without oxygen. Rigor causes the muscle to shorten which results in muscle toughening.

Therefore, the muscle contractile unit called the sarcomere must be broken down to improve tenderness which will allow the heat of cooking to further improve tenderness.

3. Meat Tenderness

Techniques for breaking down collagens in meat to make it more palatable and tender are referred to as tenderizing or tenderization. Tenderizing of beef meat is carried out by several methods: dry-aging, mechanical, thermal, chemical and enzymatic methods, treatments with ultrasound or high pressure.

Mechanical tenderization involves pounding or piercing the meat with one of those medieval looking devices. The physical action is essentially pre-chewing the meat for you. This technique not only breaking up the connective tissues that make meat tough but also breaking up the meat fibers themselves.

Conventional methods for tenderization such as modified chilling, extended ageing, altered carcass suspension and prerigor skeletal separations are not sufficient to guarantee tenderness. Calcium chloride injection was also ineffective at tenderizing the ST muscle from mature cow [7].

3.1. The Tenderization that Occurs through Cooking

Cooking of meat products is essential to achieve a palatable and safe product. The meat proteins, approximately 20% of a muscle’s weight, represent the main constituents that make up the structure of the meat product. They undergo substantial structural changes on heating and therefore the quality of the meat product, which is mainly governed by the meat structure, also changes drastically when cooking.

Most of the sarcoplasmic proteins aggregate between 40 and 60 ^{0}C, but for some of them the coagulation can extend up to 90 0C. For myofibrillar proteins in solution unfolding starts at 30–32 ^{0}C, followed by protein–protein association at 36–40 ^{0}C and subsequent gelation at

45–50 ^{0}C. At temperatures between 53 and 63 ^{0}C the collagen denaturation occurs, followed by collagen fibre shrinkage. If the collagen fibres are not stabilised by heat-resistant intermolecular bonds, it dissolves and forms gelatine on further heating [13].

Heating tenderizes meat in three distinct phases. Up to 65°C aging occurs through proteolysis at specific sites in the myofibrils. However, above 65 ^{0}C elasticity acts adversely and impairs the tenderness. The contraction of the connective tissue, mainly occurring after 65 ^{0}C gives rise to an increase in the elasticity of the meat by forming a much denser material in the temperature region of 65–80 ^{0}C and thereby a tougher meat[13]. From about 70°C the collagen of the connective tissue is denatured and melts. Above about 100°C the myofibrils begin to break down again presumably from non-specific high-temperature hydrolysis. The rate of cooking tenderizing above 70°C increases sharply with temperature and at 100°C is equal to the maximum aging rate at 60°C [6], [13].

The sensory evaluation showed that, for the whole meat, the toughness decreased drastically from 55 to 60 ^{0}C, thereafter increased again up to 80 ^{0}C [13].

By applying P–H (high pressure-heat treatment), treated samples had sharp cut ends in comparison with the raw and heat control, where the myofibres are more frayed and jagged. The sharp ends of the fibres suggest that crack propagation had been easier in the P–H treated fibres and had not been blunted as was likely for the control samples. That could be one of the reasons why the P–H treated samples were tender than other samples [12].

3.2. Enzymatic Tenderization

Twenty first century is the era of biotechnology has spread its wings towards commercially valuable complicated biochemical processes. One of its major branches is enzyme technology that makes different industrial procedures convenient, economical and simple.

Enzymes are proteins which are specialized in the catalysis of biological reactions. They are among the most remarkable biomolecules known through their specificity and amazing catalytic power.

Enzymes are biological molecules that increase the rate of a reaction. In the case of dry-aging, natural enzymes found in the meat help break down the collagen over time. It results in a tender, flavorful piece of meat without altering the structure of the meat fibers. The drawback is that it takes a long time, over 20 days, and over 1/3 of the volume of meat is lost because of moisture loss and is needed to trim the outer surfaces of the meat before cooking it [10].

Meat products manufacture uses enzymes that mimic the natural anabolic and catabolic processes of meat. Exogenous enzymes originating from plants, bacteria and fungal sources have been used for centuries to improve tenderness by proteolytic activity.

These are exogenous tenderizing enzymes such as papain, bromelain, ficin, actinidine and proteases with fungal or bacterial origin, cross-linking enzymes such as transglutaminase and tyrosinase, flavour producing enzymes.

Research into the use of exogenous proteolytic enzymes has been conducted for over 65 years and has investigated countless enzymes from plant, bacteria, and fungal sources.

Currently, five of the exogenous enzymes have been classified as ‘Generally Recognized as Safe’ (GRAS) by USDA’s Food Safety Inspection Service (FSIS) and come from varying plant: Papain, Bromelain, Ficin, bacterial: Bacillus Protease and fungal sources: Aspartic Protease [4].

Exogenous enzymes added to meat to enhance tenderness react differently to the myofibrillar and connective tissue portions of the meat. The proteins preferentially degraded by the GRAS enzymes are identified in Table 1 [4].

Table 1

Strength of hydrolysis by various enzymes [4]

Protease	Hydrolysis of myofibrillar proteins	Hydrolysis of collagen
Papain	Excellent	Moderate
Bromelain	Moderate	Excellent
Ficin	Moderate	Excellent
Aspergillus	Moderate	Poor
Bacillus	Poor	Excellent

Papain, also known as papaya proteinase I, is a cysteine protease enzyme present in papaya (*Carica papaya*) and mountain papaya (*Vasconcellea cundinamarcensis*).

The mechanism by which papain breaks peptide bonds involves the use of a catalytic triad with a deprotonated cystine [1]. Papain is a relatively heat-resistant enzyme, with an optimal temperature range of 60 and 70 °C [4].

Bromelain is the collective term for enzymes derived from the ripe and unripe fruit, as well as the stem and leaves, of the pineapple plant, Ananas comosus, a member of the Bromeliaceae family. Bromelain is mainly comprised of cysteine proteases, with smaller amounts of acid phosphatase, peroxidase, amylase and cellulase. Bromelain contains at least four distinct cysteine proteases.

In principal, enzymes may be used in two different ways to alter structure of meat. First, enzymes may catalyze breakdown of covalent bonds in proteins thereby generating smaller peptide fragments or amino acid. This structure breakdown may increase the tenderness of meat. Second, enzymes may promote the formation of new covalent bonds between meat proteins. In meat gels, such enzymes may enhance firmness and water holding capacity of gels [15].

Identifying and using the highest level of enzyme for each treatment without detrimental effects on tenderness, all treatments - Papain, Bromelain, Ficin, Aspergillus and Bacillus prove to increase tenderness of the product in comparison to the control [4].

Injection of beef cuts with proteolytic enzymes cause an important improvement of tenderness of adult beef. Papain and bromelain produced increasing of hydroxiproline and free amino acids content in boiled beef cuts [8].

Samples tenderized with a mixture of exogenous proteolytic enzymes have been recorded accumulation of non-protein nitrogen and free amino acids higher than the control samples, but no evidence to the samples tenderized only with bromelain or papain. This allows to assume that the two enzymes are hampering in their work when are used together for tenderizing meat [8].

By injecting brine supplied with enzymes - papain and bromelin there was noted a limited hydrolysis of beef meat proteins, a loss of physical integrity of muscle and connective tissue, accompanied by a high solubility of structural proteins, and an improvement of the beef meat tenderness [7].

Papain and bromelin showed hydrolytic activity on the connective tissue, leading to a better tenderization of the adult beef meat [7].

The studies showed that adding Papain in brine reduce losses during heating, increase pH and rigidity index level, obtaining a tender, pasty texture meat, with much improved resistance to pressing [5]. The Bromelain added in brine influenced the pH level, depending on the meat condition and enzymatic tenderizing time [5].

The mix of the two enzyme, Papain and Bromelain determined a higher percentage of bound water in the meat, while pH, rigidity index level and meat losses during heating registered lower values compared to individually enzyme use [5].

3.3. Treatment with Ultrasonic Radiation

The effects of ultrasonic radiation and papain treatment for improving meat tenderness were investigated on proteolytic activity, filtering residues, Warner–Bratzler shear force (WBSF), meat textural profile (TPA), and muscle microstructure [3].

Application of enzyme, either singly or coupled with ultrasound significantly decreased the filtering residue, WBSF and textural parameters. The most proteolytic activity and the highest tenderness were obtained when the combined treatment was applied at ultrasonic power of 100 W for 20 min. The combined treatment can be employed as a useful tool for the meat tenderization [3].

The effects of ultrasound radiation, enzyme treatment, and simultaneous application of both ultrasound and papain on the tenderness of beef indicate that high-intensity ultrasonic radiation coupled with enzyme treatment improves not only meat tenderness by causing disruption inmuscle integrity but also its proteolytic activity [3].

The combined ultrasound and enzyme one yielded the best tenderness results, especially when an ultrasound radiation of 100 W was applied for 20 min. It may thus be concluded that the combination of ultrasound radiation and papain treatment could be used as a promising technique for the production of tender beef pieces that might have a high potential application in meat products industries [3].

4. Conclusions

Tenderization techniques are operations used for counterworking the negative aspects of the post-mortem transformations in meat.

The main tenderizing methods in meat industry are: mechanical, chemical and enzymatic methods, treatment with ultrasound.

The enzymatic tenderization is from far the most efficient method for meat tenderization using mainly vegetative enzymatic extracts like Papain or Bromelain, even few innovative methods like treatments with ultrasound or high pressure were studied.

In order to avoid advanced structural degradation of the meat, the enzymatic treatment has to be carefully monitorized by limiting the levels of the enzymes and the tenderization period.

Depending upon the system and degree of degradation desired, each has its purpose and place within the meats industry.

Prior to deciding upon which enzyme to use, one must analyze the system in place. Factors such as raw material, holding time and temperature, other ingredients found within the brine, handling, and cooking procedures need to be evaluated to determine which enzyme will provide the desired outcome.

Even the meat scientists have examined the beef tenderness for decades, a large volume of information is still not explained and there still is a great deal of doubt that the system is this simple.

However, meat tenderizing techniques still concerns and challenge the meat scientists.

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