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Labeling of mechanically tenderized beef products: a mini review

Abstract

Mechanical tenderization of beef products involves mechanical techniques in order to break up tissue. This could lead to the introduction of pathogens from surface to the interior. Due to the huge number of outbreak reports related to mechanical tenderization since 2003, it becomes essential to standardize cooking time and instructions for consumer safety. Mandatory labeling of mechanically tenderized beef products is an innovative option to control the outbreaks. Labeling based on safe cooking time (end point internal temperature 160°F) is dependent on various factors. This review discusses the process of tenderization, pathogenic organisms associated with it and cooking time factors. It also highlights the importance and pitfalls concerning labeling of validated cooking instructions.

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Introduction

Mechanical tenderization of meat products is now a usual practice in North America.[1] Mechanical tenderization involves piercing or compression techniques to develop tenderized meat products. Growing concern of food safety with mechanical tenderization makes it essential to investigate the problem and develop control strategies. Although, mandatory labeling requirements of validated cooking instructions by U.S. Department of Agriculture's Food Safety and Inspection Service (USDA-FSIS) ensures consumer protection to an extent. But various factors governing cooking time makes it difficult to standardize or validate cooking instructions based on a particular parameter (thickness).[2] This review aims to discuss mechanical tenderization process, strains associated with contamination: its illness or disease potential, control strategies involving cooking time dependent factors, labeling requirements and its ambiguities in certain areas.

Discussion

Mechanical tenderization

Consumers judge the palatability and quality of meat products based on their tenderness.[3] To cater consumer preference, it necessitates assurance of quality tender products. Mechanical tenderization is an integral part of commercial beef processing. Mechanical tenderization of beef products guarantees continuous consistency in tenderness of beef products.[4] It enhances consumer acceptability of inadequately tender raw beef.[5] Mechanical tenderization of meat tissue in industries involves accepted techniques of blade or needlepiercing, pounding, compression and extrusion, slashing, or tumbling (massaging).[4] Blade or needle tenderization is popular in Europe and North America.[6] Blade or needle tenderization involves piercing them with closely spaced needles or small blades in order to break up the tissue or muscle fibers into shorter segments. Breaking of the connective tissue leads to release of myofibrillar proteins. Increased protein extractability causes solubilization during cooking leading to tenderness of beef muscle fibers.[7] It has been further studied that mechanical tenderization reduced cooking times, hardness, and chewiness.[8,9] Likewise they were found to increase mealiness, flavor and overall palatability.[10] Lately, due to its positive attributes and consumer preference it has become the widely accepted technique within the meat industry, hotel, restaurant, and institutional trade.[11] However, with the growing popularity of mechanical tenderization there has been issues of compromised food safety. Food safety concerns arise due to increased chances of carrying the surface bacterial microflora into previously sterile deep tissues with piercing of needles of blades.[12] If cooked thoroughly, chances of contamination hazard is fairly low. But consumer preference for rare and medium cooked beef leads to survivability of contaminated pathogenic in underdone tissues.[13] Among the pathogenic microflora studied tracing sources of contamination, Shiga toxigenic (STEC) *Escherichia coli* O157:H7 (*E. coli* O157:H7) and Non-O157:H7 and *Salmonella* species were found to be most abundant.[14] Since 2000, the Center for Disease Control and Prevention (CDC) reported and identified *E. coli* O157:H7 as the causal microorganism of six outbreaks linked to needle or blade tenderized beef products.[15] Likewise, in Canada *E. coli* O157:H7 was responsible for 18 food borne illness followed by an outbreak.[16] Therefore, it becomes essential to review the concerned microbe: its occurrence, illness, and disease causing potential to design effective control strategies.

Pathogens commonly associated with tenderized beef products contamination

The global economic burden of pathogenic microbial contamination of beef products is estimated to be billions of dollars every year because of recalls, disposals, and health care costs. Recalls of food due to microbial contamination accounted for 25% of all food recalls in the US between October 1991 and September 1992.[17] Moreover, contamination issues with foods is playing an increasingly important role in the economy of many countries having devastating effects on their foreign trade.[17] On the other hand, microbial contamination of foods may cause severe economic losses to processing companies or entire industries if the microbial hazards are not recognized timely.[17] So it becomes essential to recognize microbial hazards related to mechanically tenderized beef products. Some of the commonly associated microbial pathogens include: shiga toxin producing *Escherichia coli* O157:H7 and Non- O157:H7 (STEC), and *Salmonella*.

STEC and *Salmonella* spp. are a part of the natural flora in the gastrointestinal tract of cattle and are shed in the feces which can sully the cattle hide leading to pathogen attachment where they persist for extended periods of time. Cattle hide was found to be the major source of STEC and *Salmonella* spp.[18] Muscle and fat tissue surfaces beneath the hide of healthy cattle are essentially sterile, but they become contaminated when the carcasses come in contact with the hide during animal processing.[18] Moreover, high prevalence of *Escherichia coli* O157:H7 around 76% in cattle hides entering commercial beef plants makes it more vulnerable to contamination.[19]

The STEC was first identified in 1982 as a human pathogen from two outbreaks of hemorrhagic colitis (HC) occurred due to consumption of undercooked hamburger patties.[20] The STEC infections showed distinctive clinical symptoms such as abdominal cramps, bloody stools with little or no fever. Subsequently Karmali et al.[21] found its association with shiga like toxin production and post-diarrheal hemolytic uremic syndrome (HUS) which causes acute renal injury, and thrombocytopenia. It was reported that toxin was produced by diarrheagenic *E. coli* that had same immunological and functional characteristics as of *Shigelladysenteriae.*[22] According to recent estimates of CDC, 48 million cases of food borne illness that occur every year, affect one in six Americans. More than 96,534 food borne illness and 61 deaths each year in the US are linked to *E. coli* O157:H7 infections.[23] Since 1998-2008, 350 *E. coli* O157:H7 associated outbreaks (52% food borne) were reported in 49 states, of which six of them were traced back to mechanically tenderized beef products.[24] These studies suggest that *E. coli* O157 have emerged as an important human pathogen of public health concern. Other *E. coli* serotypes that can produce Shiga toxins and cause diarrhea, hemorrhagic colitis, and HUS have been emerged over the years.[25] These new STEC serotype named non-O157 *E. coli* have emanated and are reported to cause 287,000 cases of illnesses each year contributing to the public burden of human infections and clinical diseases.[23] According to the CDC in the year 2010 non-O157 *E. coli* serogroups collectively caused more human infections than *E. coli* O157:H7 in the US. It has been estimated that approximately 70% of the non-O157 STEC infections that emerged from 1983 to 2002 were caused by one of six major serotypes, which are now referred to as ‘‘the big six,’’ including O26, O45, O103, O111, O121, and O145.[26] There have been 46 outbreaks attributed to these non-O157 *E. coli* strains alone in the US from 1990 to 2010; 84% of the illnesses in these outbreaks were food borne. Those 46 outbreaks were categorically attributed to O111 (14), O26 (11), O121 (5), O45 (4), O145 (2), O103 (2), and O104 (1).[27] Therefore, it is evident that recently emerged non-O157 *E. coli* threatens public health and has been declared as an adulterant in non-intact beef by USDA.

With the ability to abode at ease in the gastrointestinal tract, *Salmonella* is the next big concern as causative agent of food borne illness. From 2009 to 2010, it resulted in the largest number of reported hospitalizations in US due to food borne disease outbreaks.[18] *Salmonella* serotypes are linked to human Salmonellosis. There are 2449 known serotypes of *Salmonella.*[28] Among the known serotypes, *Salmonella Typhimurium (S. Typhimurium), Salmonella Newport* (*S. Newport*) and *Salmonella Enteritidis* (*S. Enteritidis)* are the most commonly associated with food borne out breaks. From all the mentioned serotypes, *S. Typhimurium* caused havoc amounting to 458cases of illness with 49cases of hospitalization in the US and 813cases of illness in European countries like Iceland, the Netherland, the U.K., Germany and Finland.[29–32] *Salmonella* is highly adaptive pathogen that can survive a range of adverse environmental conditions. These extreme conditions include desiccation and starvation, which the bacterium survives by reducing its cell surface area and minimizing metabolic activity. *Salmonella* spp. is also able to tolerate acidic conditions and have the ability to remain viable even in low relative humidity, and can withstand sunlight for at least 10days making it one of the most difficult organism to control.

Control strategies and labeling requirements

It becomes essential to control the growing number of food borne outbreaks linked to consumption of mechanically tenderized steaks due to STEC and *Salmonella* spp. Swanson et al.[33] identified failure in effective cooking of mechanically tenderized raw or partially cooked beef product as a significant factor in related outbreaks.[33] This necessitates to develop scientific cooking procedure based on temperature profile of meat, number of flipping’s, and cooking time dependent factors.[1,14] Previous studies and USDA-FSIS[34] have suggested that maintaining a consistent temperature in beef products assured complete lethality of pathogenic flora.[1] In order to achieve consistency in temperature profile throughout cooking it necessitates full thawing before cooking.[35] Along with thawing, the end point internal temperature of the cooked steak should reach 160°F to assure complete log reduction (5log$_{10}$) of pathogenic microflora like STEC and *Salmonella*. Studies in the past have standardized cooking temperatures and rest time needed to ensure 5 log$_{10}$ reduction (Table 1).

Table 1 Cooking temperature and rest time to ensure complete reduction (5 log$_{10}$ reduction) during cooking of mechanically tenderized steaks

Pathogen	Cooking temperature	Rest time	Reference
Salmonella and *Escherichia coli* O157:H7	145°F	3minutes	
	150°F	52seconds	37,38
	Above 160°F	No rest time	

Flipping of mechanically tenderized steaks is an essential factor deciding fate of pathogenic microflora. A study by Gill et al.[1] identified more consistent reductions in *E. coli* O157:H7in those steaks which were flipped twice rather than turning them over once. Increased number of flipping’s during cooking of mechanically tenderized steaks ensured consistent achievement of desired endpoint temperature throughout the steak.

In lines with control strategy through scientific cooking method, mandatory labelling requirements for NRTE mechanically tenderized steak products were announced by USDA-FSIS. Labeling requirements warrants safety of mechanically tenderized beef products based on validated cooking instructions. Validation of cooking instructions on the label is an integral part of food safety. Validated cooking instructions are generally standardized based on above mentioned factors and standard thickness[34] of steaks. However, previous studies have shown multiple cooking time dependent factors like water content, humidity, type of meat and cooking method.[36] Similar studies conducted in our facility have shown significant variation in safe cooking time (internal temperature: 160°F) according to weights (identical thickness), water content and type of meat (unpublished data). Moreover, it was also observed that cooking time varied according to both subprimals and steak cuts (Strips-Strip loin etc., Chuck, Teres Major etc.). Therefore

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it becomes essential to conduct further studies on cooking validation procedures considering multiple factors for formulating labeling requirements of mechanically tenderized steak products. Although, large meat processing industries have specific product line (constant thickness and weight) that warrants validation of cooking instructions. But consumer preference for customized thickness and cuts from small and medium producers makes it difficult to generate validated cooking instruction labels. This makes both the processor and consumer vulnerable to contamination issues following legal hazards.

Conclusion

Foodborne illnesses are now considered as one of the most prevalent problems across the world. Consumer preference for minimal processing with antimicrobials and consumption patterns of raw to medium rare has left the industries with narrow spectrum. Effective research investigating various cooking time dependent factors is essential to formulate effective cooking instructions. Standardized cooking based on thickness needs further study. It also necessitates to incorporate multiple factors (meat type, cooking method, pH, fat and water content, collagen content) to decide safe cooking time. No specified guidelines for small and medium scale processors selling customized steak products increases risk of contamination hazards. Effective risk evaluation of small and medium scale meat processors and designing mitigation strategies is the need of the hour.

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Conflict of interest

The author declares no conflict of interest.

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