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PEER-REVIEWED ARTICLE

Food Protection Trends, Vol 38, No. 3, p. 171–177

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Prevalence and Conditions of Mechanical Tenderization and Enhancement of Beef at Independent and Minor Chain Meat Retailers in North Carolina

ABSTRACT

Mechanical tenderization and enhancement are processes used to improve sensory attributes of beef. Beef products that have been mechanically tenderized or enhanced may carry greater foodborne illness risks than intact beef because of introduction of pathogens into the meat. The resulting heightened risk requires various risk management steps, such as stricter time/temperature cooking combinations for pathogen destruction. Approximately 10.5% of beef products produced from manufacturing facilities in the United States are mechanically tenderized; however, little is known about the prevalence of this process in retail settings. A semi-structured interview was employed with meat retailers to determine the prevalence of mechanical tenderization and enhancement of beef onsite. Information about equipment used, the cuts and thickness of beef used, and product storage parameters were collected. Of the 85 independent and minor chain meat retailers in the sample site (Wake, Durham, and Orange counties in North Carolina), 23 meat retailers mechanically tenderize or enhance beef products onsite. Self-reported practices suggested that meat retailer personnel handle mechanically tenderized beef without focusing on specific risk-reduction practices The results of this work can be used to design educational materials for meat retailers and staff.

INTRODUCTION

Some cuts of beef are mechanically tenderized and/or enhanced to add value to lower quality cuts by improving sensory attributes such as palatability and tenderness *(1, 7, 20)*. The term "mechanically tenderized" is defined by the Food Code as "manipulating meat with deep penetration by processes which may be referred to as "blade tenderizing," "jaccarding," "pinning," "needling," or using blades, pins, needles or any mechanical device" *(4)*. This definition does not include processes by which solutions are injected into meat, commonly referred to as enhancement *(4)*.

In 2016, the United States Department of Agriculture Food Safety and Inspection Service (USDA FSIS) published a final rule requiring raw or partially cooked beef that is mechanically tenderized using a needle or blade, and products injected with marinade or enhancement solutions, to be labeled unless such product is destined to be fully cooked or to receive another full lethality treatment *(18)*. The final rule does not apply to beef products that have been

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pounded or cubed, enzyme formed, or vacuum tumbled (with or without marinade or enhancement solutions).

Greater microbial risk is associated with mechanically tenderized and enhanced beef products than with intact beef products, because pathogens potentially residing on the meat surface can become internalized into beef subprimals or transferred by cross-contamination of subprimals if liquid/marinade is reused after coming into contact with beef containing pathogens *(9, 14, 16)*. Since 2000, six confirmed outbreaks illness caused by *E. coli* O157:H7 have been associated with undercooked needle- or blade-tenderized beef products in the United States *(18)*. Additionally, an outbreak caused by *E. coli* O157:H7 in Canada was associated with consumption of undercooked mechanically tenderized beef that had been tenderized at retail *(2, 18)*.

Because of this increased risk, different consumer cooking recommendations exist for these products. The labeling rule (Docket No. FSIS-2008-0017) states that the label should include a description designation (i.e., mechanically tenderized, blade tenderized, or needle tenderized) and validated cooking instructions specifying the minimum internal temperature and any hold or "dwell" times to ensure that products are fully cooked *(18)*.

Equipment used to mechanically tenderize and enhance beef products can be challenging to clean and sanitize because of complex construction and difficulty of disassembling it. Improper cleaning and sanitation practices can allow pathogens to persist within niches of the equipment, resulting in subsequent contaminated meat *(21)*. Because pathogens have been shown to persist in commercial marinades *(10, 13)*, incorporating marinades and solutions into beef products by mechanical tenderization and enhancement creates an additional avenue for potential pathogen contamination in the absence of proper cleaning and sanitation of equipment. Various approaches are used to mechanically tenderize and enhance beef products.

There are an estimated 555 manufacturing facilities that blade or needle tenderizes beef products in the United States (251 very small, 291 small, and 13 large establishments) *(11, 18)*. Approximately 10.5% of total beef products sold annually, or about 2.6 billion pounds, are mechanically tenderized *(11, 18)*. Of these products, an estimated 479 million pounds were packaged in retail operations *(11, 18)*. The USDA FSIS labeling rule does not estimate the number of retail establishments that would be involved with repackaging raw or partially cooked mechanically tenderized beef products or the number of labels they would require to be in compliance with this rule *(18)*. FSIS believes that "the number of retailers involved in repackaging mechanically tenderized beef is small and declining, with large retailers and warehouse clubs moving toward ordering case-ready packaged beef products" *(18)* and that "very few retail facilities are producing mechanically tenderized beef"; however, there are few or no data provided to support this estimation. To date, no studies have investigated the prevalence of mechanical tenderization and enhancement of beef at retail. The purpose of this study was to explore the prevalence of mechanical tenderization and enhancement of beef prepared onsite at independent and minor-chain meat retailers and document the types of practices that are used.

MATERIALS AND METHODS

A convenience sample of meat retailers in Wake, Durham, and Orange counties in North Carolina was used for the study. A list of inspected facilities was obtained from the local health department in each of the three counties. Each list contained all permitted facilities (both food and non-food) inspected by the local health department. Google searches (www.google.com) were then performed to determine which food establishments from the lists sold raw or partially cooked beef products intended for consumer preparation within the home. Meat retailer (meat markets, restaurants with separate meat counters, or food stands) names and addresses were used as search terms. Electronic searches were conducted from May 2015 to June 2016. Telephone calls were used as a second confirmation method if the sale of raw or partially cooked beef products by an establishment could not be determined through Google searches alone.

After this list of establishments was created, all independently run and minor-chain locations selling beef were visited in person to conduct interviews with personnel, with the top 75 retailers (in 2015) being excluded *(15)*. Minor and independent chain locations were chosen to illustrate a specific population of food establishments. The top 75 retailers were excluded from the study as a way to designate the difference between the terms "independent" and "minor" versus "chain" establishments, because of the absence of an accepted definition that could be used to distinguish them from one another. Interviews included questions on business practices related to mechanical tenderization and enhancement of beef products, as well as sanitation of equipment. Questions asked were limited to business practices only. No information about knowledge, opinions, or individual practices (such as handwashing) was collected; all data collected and presented is therefore not linked to individuals and IRB approval was not required, because this was not human subject research.

Interviewers

Six trained interviewers conducted the interviews in the food establishments. A specific interview script was used to compensate for any differences among interviewers. All responses were compiled into a shared database after completion of each interview. Using in-person interviews to collect the data provided the researchers with considerable control over who completed the interview *(3)*.

Meat retailer visits

Establishments that met the selection criteria were visited unannounced by one or two interviewers. Upon arrival, the interviewers first asked for a meat counter manager or general manager. If no manager was present, other employees who handle meat were asked to agree to an interview. If an establishment was not available for an in-person interview at the time the interviewers arrived, an in-person meeting or telephone interview was scheduled for another time. Before the survey was administered, interviewers revealed they were conducting research and that the participant could decline to participate.

Once the interview was consented to, a semi-structured interview was conducted to characterize prevalence of on-site mechanical tenderization and enhancement of beef taking place. Semi-structured interviews were chosen as a tool to lead conversation in a standardized way, while still allowing opportunities for relevant issues to emerge *(12)*. Interview questions have been made available at https://foodsafety.ces.ncsu.edu/research-3/.

Because the terms "mechanical tenderization" and "enhancement" have various meanings and may not be understood by retailers, a scripted introduction was recited before the participant was asked specific interview questions to describe the processes of mechanical tenderization and enhancement. In the interview script, mechanical tenderization was described as using needles or blades to breakdown and penetrate muscle fibers. Mechanical tenderization was also described as occurring when marinade or tenderizing solution is injected into muscle fibers. Examples of mechanical tenderization such as cubing, blade tenderizing, and needle tenderizing were provided for reference. Needle injection, vacuum tumbling, and marinating before mechanical tenderization were given as examples of enhancement. If a meat retailer was not mechanically tenderizing or enhancing beef products onsite, no further questions were asked.

If it was determined that the retailer was mechanically tenderizing and/or enhancing beef onsite, additional information was collected to understand the retailer's specific practices. Data were gathered through interview questions that pertained to both quantitative and qualitative aspects of the practices associated with mechanically tenderized and enhanced beef products. Questions were asked about types of meat (cuts and thickness) that were mechanically tenderized and enhanced; equipment used to mechanically tenderize or enhance; how that equipment was cleaned and sanitized; the specific storage parameters of beef and marinade/brine (if used), and formulations of marinade or enhancement solutions.

Pilot-testing interview methodology

Interview questions were pre-tested at independent and minor-chain meat markets selling raw or partially cooked beef within a local jurisdiction, inspected four times per year. Pre-testing was implemented to ensure that familiar terminology was being used for meat retailer employee understanding. Once additional information was gathered to further characterize mechanical tenderization and enhancement of beef at retail, additional questions were added to the original interview. Meat markets that had been visited for pre-testing were revisited with the modified interview script.

RESULTS

Prevalence

Out of 4,353 permitted food establishments (both chain and independent establishments) in Wake, Durham, and Orange counties, approximately 200 sold raw or partially cooked beef. Of the establishments selling raw or partially cooked beef, 85 were independently run or were classified as part of a minor chain. All 85 of these establishments were visited in this study. Twenty-three (27.1%) of the independent and minor chain retailers visited were mechanically tenderizing or enhancing beef products onsite (11 in Wake County, 7 in Durham County, and 5 in Orange County). Mechanical tenderization was more prevalent than enhancement with liquid. *Table 1* shows the prevalence of mechanical tenderization and enhancement in each county.

Not all products produced by mechanical tenderization practices are required to be labeled as such. Beef products found at the sample site that were mechanically tenderized or enhanced by processes such as cubing, or vacuum tumbling, or by way of mallet (pounding), do not fall under the labeling rule. On the basis of the practices being employed by the retailers, 5 of the 23 (21.7%) meat retailers mechanically tenderizing or enhancing beef onsite would be required to label the product per Docket No. FSIS-2008-0017.

Temperature

Twenty of the 23 retailers reported holding products at 40°F or below, before tenderization, although one retailer kept products between 44 and 45°F *(Table 2)*. Two of the retailers did not know or would not disclose information regarding pre-tenderization temperatures. Following tenderization, according to 21 retailers, products were kept at 40°F or below, with one retailer keeping products between 39 and 41°F. One retailer gave products to customers immediately after tenderizing the products. One retailer did not know or would not disclose information regarding the holding temperatures after tenderization.

Cuts and thickness

When asked what cuts of beef are tenderized, 15 meat retailer personnel mentioned cuts coming from the round (top round, bottom round, and eye of round specifically mentioned), 4 from the loin (bottom loin, beef tips, and sirloin cap specifically mentioned), 2 from the chuck (chuck eye specifically mentioned), and 1 from the flank *(Table 2)*. Four

TABLE 1. Establishments employing specific mechanical tenderization and enhancement methods in Wake, Durham, and Orange Counties (n = 23)

	County		
Practice	**Wake**	**Durham**	**Orange**
Mechanical tenderization method			
Blade or needling tenderizing*	3	1	1
Cubing	6	6	4
Pounding	2	-	-
Total	**11**	**7**	**5**
Enhancement with liquid			
Vacuum tumbling with liquid	2	-	-
Marinating/brining already tenderized (by blade/needle) beef*	1	-	1
Total	**3**	**0**	**1**

*This practice falls under the labeling rule

meat retailer personnel did not know or would not disclose information about the cuts of beef being tenderized. When asked what thickness of beef is mechanically tenderized at the establishment, three meat retailers used 2 to 2 ¼" thickness, five used 1 to 1 ¼" thickness, six used ¼" to ¾" thickness, and one used 1/8" thickness *(Table 2)*. Eight did not know or would not disclose information about thickness of the cuts of beef that were mechanically tenderized.

Equipment

Hobart brand meat tenderizer models, commonly used for cubing, were overwhelmingly the primary tools used among meat retailers for mechanical tenderization of beef products. Sixteen retailers cubed beef using a Hobart Meat Tenderizer, with two retailers using models that were similar but produced by a different manufacturer (Berkel and Procut KT8). Five retailers used hand-held tenderizers/Jaccard tools such as the Chef Master and SR Needle Charger models. Two retailers used vacuum tumblers to mechanically tenderize/enhance beef products. Two retailers used mallets for tenderization purposes, while one retailer did not know or would not disclose information about the type of equipment used for tenderization *(Table 3)*. One of the meat retailers that vacuum tumbled meat with added marinade disclosed that a Daniels Food Equipment DVTS 200 model was used, while the other retailer did not disclose information about the equipment used to vacuum tumble products *(Table 3)*.

Cleaning and sanitation

When asked how frequently equipment used to mechanically tenderize and enhance beef was cleaned and sanitized, 8 meat retailer personnel said after every use and 4 meat retailer personnel said between 1 and 2 times per day *(Table 2)*. Eleven meat retailer personnel did not know or would not disclose information about frequency of cleaning and sanitizing of equipment. Twenty-two meat retailer personnel mentioned some type of sanitizing or chemical step when asked about cleaning and sanitizing procedures. One retailer used only soap and water to clean equipment, and one retailer did not know or would not disclose information about cleaning and sanitizing procedures.

DISCUSSION

FSIS has previously estimated on the basis of anecdotal information that the number of retail facilities conducting mechanical tenderization is very low; however, until now there have been no data on occurrence of these practices. This exploratory study confirmed that mechanical tenderization occurs at retail at rates higher than expected. Approximately 30% of retailers in the counties investigated are conducting this practice. Five of these retailers are mechanically tenderizing beef in a way that would require labeling. While these retailers are required to label these products as per the USDA FSIS labeling rule, the enforcement of food protection in these retail facilities is conducted by local health departments, which in many jurisdictions in the U.S. employ a version of the FDA's model food code, which does not currently include the newly effective labeling requirements (2013) *(4)*. This population of processors can be seen as existing in a gap for proactive regulatory action and also from outreach with regard to tenderizing practices.

TABLE 2. Temperature control, cleaning and sanitizing procedures and cuts and thicknesses of beef used by independent and minor chain meat retailers (n = 23)

Correct temperature control	Frequency
Prior to processing	20
After processing	21
Would not disclose/did not know	2 (prior), 1 (after)
Cleaning and sanitizing (C&S) practices	
C&S after every use	8
C&S once or twice/day	4
Incorporated a sanitizing step	22
Would not disclose/did not know	11 (frequency), 1 (sanitation)
Cuts of beef	
Round	15
Loin	4
Chuck	2
Flank	1
Would not disclose/did not know	1
Thickness of beef cut	
2 to 2 ¼"	3
1 to 1 ¼"	5
¼" to ¾"	6
⅛"	1
Would not disclose/did not know	8

TABLE 3. Models of equipment used to mechanically tenderize and enhance beef products

Mechanism	Model
Hand-held needle or blade tenderizers	Chef-master Blade Meat Tenderizer
	Jaccard Meat Tenderizer
	Steven Raichlen Marinade
	Turbocharger
Cubing devices	Hobart Meat Tenderizer (various models)
	Berkel Tenderizer
	Pro-Cut KT-8 Meat Tenderizer
Vacuum tumblers	Daniels Food Equipment
	DVTS 200

The self-reported business data related to handling, communication and sanitation demonstrate a need to create educational interventions for this population, not only for compliance to labeling, but also regarding safe practices specific to mechanically tenderizing beef. Generally, the 23 retailers interviewed were using safe practices with regard to correctly

controlling temperature before and after processing, and using proper sanitation. There was room for improvement or clarification with a few of the retailers. Overall, it can be concluded that intervention in necessary to ensure adequate knowledge and safe practices to verify adequate risk management. Since mechanically tenderized and enhanced beef products have been classified as higher risk compared with those that remain intact, meat retailers must take additional steps to reduce risk before the product reaches the consumer.

Beef that is mechanically tenderized or enhanced by processes such as cubing or vacuum tumbling, or by way of mallet (pounding), do not fall under the labeling rule, despite also being considered higher-risk than intact beef *(18)*. Docket No. FSIS-2008-0017, *Descriptive Designation for Needle- or Blade-Tenderized (Mechanically Tenderized) Beef Products* states that even though vacuum tumbled beef products are processed in a manner that may introduce pathogens (if present) below the product's surface, the final rule will not apply to them *(18)*. Additionally, the rule states that tenderization methods that change the appearance of the product, such as pounding (using a mallet) or cubing, indicate to the consumer that the product is non-intact *(18)*. It is inferred that if the process changes the appearance of the meat, then the consumer should assume it should be handled differently and therefore it does not require additional labeling *(18)*. These statements assume that the consumer can always visually tell that raw or partially cooked beef products have been manipulated in a way that increases the risks associated with the product and therefore must be handled in a different way (i.e., cooking non-intact beef to a higher temperature than intact beef). FSIS concluded that there was not sufficient data to establish whether the risk that pathogens may be introduced into product as a result of vacuum tumbling is similar to that associated with needle and blade tenderized beef *(18)*. Foster-Bey et al., comparing blade-tenderized beef and vacuum-tumbled beef, concluded that regardless of how steaks were manipulated, inoculated pathogens (STEC-8 cocktail) were translocated into the deeper tissues of the subprimal, and cooking was effective in reducing appreciable levels of STEC *(6, 19)*.

Various interpretations exist as to what constitutes a beef product as mechanically tenderized or enhanced/marinated, leading to confusion. Cubing or pounding beef, the most frequent means of mechanically tenderizing beef at the sample site, is considered "mechanically tenderized" per the 2013 Model Food Code but does not fall under the requirements for Docket No. FSIS-2008-0017: *Descriptive Designation for Needle- or Blade-Tenderized (Mechanically Tenderized) Beef (4, 18)*. The term "mechanically tenderized" is defined by the 2013 Model Food Code as manipulating meat with deep penetration by processes *(4)*. The 2013 Model Food Code specifies that the term "mechanically tenderized" does not include processes by which solutions are injected into meat, but Docket No. FSIS-2008-0017 requires the use of the descriptive designation "mechanically tenderized," "blade tenderized," or "needle tenderized" on the labels of raw or partially cooked needle- or blade-tenderized beef products, including beef products injected with a marinade or solution *(4, 18)*. Vacuum-tumbled beef can incorporate marinade or enhancement solutions as found at the sample site but is not considered to be mechanically tenderized by either the 2013 Model Food Code definition or Docket No. FSIS-2008-0017. The diversified descriptions of mechanically tenderized and enhanced/marinated at times conflict with one another and therefore make these types of products difficult to regulate.

Proper refrigeration temperatures are necessary to reduce the risk of growth of pathogens, if present. One retailer reported holding beef intended for mechanical tenderization at between 44 and 45°F rather than at the refrigeration temperatures (40°F or below) recommended by the USDA *(17)*. Although holding beef between 44 and 45°F is not an infraction of the 2009 Food Code, which North Carolina employed at the time of the study, this suggests that meat retailer personnel may not treat mechanically tenderized meat and enhanced beef differently from intact beef *(5)*. Proper cleaning and sanitation of equipment used to tenderize meat is needed to prevent cross-contamination between batches. Some retailers reported cleaning and sanitizing after every use, while others did so only 1 or 2 times per day. Improper or infrequent cleaning and sanitation of equipment used to mechanically tenderize and enhance beef indicates that extra precaution is not being taken concerning these high-risk products. Multiple retailers did not know or did not disclose information about the refrigeration temperatures at which they kept beef intended for mechanical tenderization, cleaning and sanitizing procedures, or the frequency of cleaning and sanitizing equipment. This suggests that meat retailer personnel may not be aware of or may not be implementing good practices regarding refrigeration temperatures and/or cleaning and sanitation of equipment.

Meat retail establishments examined in this study were often found within close proximity of each other and were observed to be niche ethnic markets. Many of the retailers mechanically tenderizing or enhancing beef products were identified as markets serving minority races/ethnicities. This frequently resulted in language barriers between the interviewers and meat retailer personnel.

Prior to this study, no information was available as to whether mechanical tenderizing or enhancement of beef was being performed onsite. Now that the prevalence and parameters of these processes are better understood, meat retailer managers and employees can be educated about food safety practices that could potentially reduce the risks associated with these types of products. Educational materials must be developed to serve a larger population of the public. As culturally unique food handling behaviors

have been found to exist within minority racial-ethnic populations in their homes, these behaviors may also enter into the retail setting *(8)*. Therefore, educational materials must be created for both English and non-English speakers in a way that addresses risk reduction strategies specific to the food handling behaviors associated with minority racial-ethnic groups.

ACKNOWLEDGMENT

This material is based upon work that is supported by the National Institute of Food and Agriculture, U.S. Department of Agriculture, under award number #2012-68003-30155.

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