

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

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## **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 by introducing pathogens inside of the meat. This heightened risk requires different 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 in retail settings. A semi-structured interview was employed with meat retailers to characterize the prevalence of mechanical tenderization and enhancement of beef taking place on-site. Information about equipment used, the cuts and thickness of beef used, and product storage parameters was 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 on-site. 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 like 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 pounded or cubed, enzyme-formed, or vacuum tumbled (with or without marinade or enhancement solutions).

There is greater microbial risk 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, there have been six confirmed outbreaks of *E. coli* O157:H7 associated with undercooked needle or blade tenderized beef products in the United States (18). Additionally, an outbreak of *E. coli* O157:H7 occurring in Canada was associated with the

consumption of undercooked mechanically tenderized beef, which had been tenderized at retail (2, 18).

Due to this increased risk there are different consumer cooking recommendations 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 due to complex construction and inability to disassemble. Improper cleaning and sanitation practices can allow pathogens to persist within niches of the equipment, resulting in subsequent contaminated meat (21). 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 unless proper cleaning and sanitation of equipment is implemented. Various approaches are used to mechanically tenderize and enhance beef products.

It is estimated that there are 555 manufacturing facilities that blade or needle tenderize 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, or about 2.6 billion pounds, are mechanically tenderized annually (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). FSIS that “very few retail facilities are producing mechanically tenderized beef,” however there is little to 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 on-site 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](http://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 (permitted as 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, due to the absence of a principal definition 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 of meat retailers were limited only to business practices - no knowledge, opinion, or individual practice data (such as handwashing) was collected; all data collected and presented is therefore not linked to individuals and IRB approval was not required. This was not human subject research, data collected was on business practices.

### **Interviewers**

Six trained interviewers conducted the interviews to different food establishments. A specific interview script was used to account for any differences between interviewers. All data was compiled into a shared database after completing each interview. Using in-person interviews to collect the data provided the researchers with more 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 that handle meat were requested for an interview. If an establishment was not available for an in-person interview at the time of arrival, 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 participation.

Once the interview was consented to, a semi-structured interview was conducted to characterize prevalence of mechanical tenderization and enhancement of beef taking place on-site. 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 process of mechanical tenderization and enhancement. In the interview script, mechanical tenderization was described as using needles or blades to break-down 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 their beef products on-site, no further questions were asked.

If it was determined that the retailer was mechanically tenderizing and/or enhancing beef on-site, additional information was collected to understand the retailers 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 more 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 the three North Carolina counties (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 a minor chain. All 85 independent and minor chain 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 on-site (11 in Wake County, 7 in Durham County, and 5 in Orange County). Mechanical tenderization was

more prevalent than enhancement with liquid. Table 1 describes the prevalence of mechanical tenderization and enhancement in each county.

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

### **Temperature**

Before tenderization, 20 of the 23 retailers reported holding products at 40°F or below, 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, 21 retailers said that products were kept at 40°F or below with one retailer keeping products between 39 and 41°F. One meat retailer gave products to customers immediately after tenderization. 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 coming from the loin (bottom loin, beef tips, and sirloin cap specifically mentioned), 2 coming from the chuck (chuck eye specifically mentioned), and 1 coming from the flank (Table 2). Four 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, 3 meat retailers used 2 to 2 ¼” thickness, 5 used 1 to 1 ¼” thickness, 6 used ¼” to ¾” thickness, and 1 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 tool used among meat retailers for mechanical tenderization of beef products. Sixteen retailers cubed beef using a Hobart Meat Tenderizer with 2 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 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 their 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 to 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 anecdotally that the number of retail facilities conducting mechanical tenderization is very low, however, until now there has not been any data to support 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, who 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 around tenderizing practices.

The self reported business data related to handling, communication and sanitation demonstrates a need to create educational interventions for this population, for not only compliance to labeling, but also on safe practices specific to mechanically tenderizing beef. Generally, the 23 retailers interviewed were using safe practices in regards 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 is necessary to ensure adequate knowledge and safe practices to verify risk

management. Since mechanically tenderized and enhanced beef products have been classified as higher risk than 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, 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 (i.e. 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, therefore 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 requires them to handle the product 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 understand 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). Research conducted by 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 to reduce 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 between 44 and 45°F rather than at 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 and enhanced beef differently than intact beef (5). Proper cleaning and sanitation of equipment used to tenderize is needed to

prevent cross contamination between batches. Some retailers reported cleaning and sanitizing after every use, while others only did so 1 to 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 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 in which they cleaned and sanitized 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 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, there was no information available if mechanical tenderizing or enhancement of beef was being performed on-site. 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 surrounding 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.

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**TABLES**

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

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

*\*This practice falls under the labeling rule*

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

<b>Correct temperature control</b>	<b>Frequency</b>
Prior to processing	20
After processing	21
Would not disclose/did not know	2 (prior), 1 (after)
<b>Cleaning and sanitizing (C&amp;S) practices</b>	
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)
<b>Cuts of beef</b>	
Round	15
Loin	4
Chuck	2
Flank	1
Would not disclose/did not know	1
<b>Thickness of beef cut</b>	
2 to 2 1/4"	3
1 to 1 1/4"	5
1/4" to 3/4"	6
1/8"	1
Would not disclose/did not know	8

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

<b>Mechanism</b>	<b>Model</b>
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