

Consumer Responses to Proposed Instructions for Cooking Mechanically Tenderized Beef Steaks

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Abstract

Mechanical tenderizing of beef can result in bacteria, which may include enteric pathogens such as *Escherichia coli* O157:H7, from the surface being carried into previously sterile deep tissues. A telephone survey of 1021 Canadian consumers was conducted during September 2013 to determine current steak cooking practices, and responses to proposed instructions for cooking to ensure microbiological safety intended for labels on packs of mechanically tenderized beef (MTB) steaks. The responses indicated that 95% of Canadian consumers preferably cook steaks to a medium rare or more well done condition while 66% turn steaks over twice or more during cooking. These practices are those required to ensure the microbiological safety of MTB steaks. Apparently, over 80% of consumers would have no difficulty understanding, and would be likely to follow instructions that specify these practices for the safe cooking of MTB steaks.

Keywords: mechanically tenderized beef, beef steaks, microbiological safety, cooking, labelling

1. Introduction

Much beef in the forms of steaks or roasts available at retail stores or prepared at restaurants in North America has been mechanically tenderized by incising the meat with banks of thin blades (Muth, Ball, & Coglaiti, 2012). This type of tenderizing treatment can result in bacteria from the surface being carried into the previously sterile deep tissues (Johns, Bratcher, Kerth, & McCaskey, 2011). Bacteria on the surfaces of beef cuts can include enteric pathogens such as *Escherichia coli* O157:H7 (Stopforth, Lopes, Schultz, Miksch, & Samadpour, 2006). *E. coli* O157:H7 infections are typically characterized by diarrhea and hemorrhagic colitis and can lead to hemolytic uremic syndrome (HUS), a life-threatening sequelae with a 5% fatality rate (Banatvala, Griffin, Greene, Barrett, Bibb, Green, & Wells, 2001). Despite much effort has been made to control the contamination of beef with *E. coli* O157:H7, outbreaks of the pathogen associated with consumption of beef continue to occur (Centres for Disease control and Prevention, 2014; Lewis, Corriveau, & Osborne, 2013). Enteric pathogens in the deep tissues of MTB might survive to be consumed if the meat is not adequately heated during cooking (Yoon, Mukherjee, Belk, Scanga, Smith, & Sofos, 2009). Even so, the risk of consumers acquiring enteric pathogens from MTB was initially assessed as being slightly greater than the risk from intact meat (US Department of Agriculture, 2002). However, recent outbreaks of *E. coli* O157:H7 in the USA and Canada associated with MTB prompted reassessment of the microbiological risks, with findings that the risks from MTB, though small, were greater than previously thought (Catford et al., 2013; U.S. Department of Agriculture, 2012). Consequently, Canadian and U.S. regulatory authorities proposed that MTB products should be labelled as such, and that labels should carry instructions for cooking the products to ensure their microbiological safety (Government of Canada, Department of Health, 2014; U.S. Department of Agriculture, 2012).

The U.S. Department of Agriculture/Food Safety and Inspection Service (USDA/FSIS) criterion for cooking treatments that will ensure the microbiological safety of items of non-intact beef products is that heating during cooking should inactivate >5 log cfu of *E. coli* O157:H7 at all points in each item (U.S. Department of Agriculture, 2013a). To deduce safe cooking conditions for MTB, the USDA/FSIS assumed that all points in a cooked item would attain temperatures above that attained at the geometric centre of the item; that the temperature at the centre would persist, or possibly rise for some time after cooking ended; and that, at any lethal temperature attained during cooking, the thermal inactivation of *E. coli* O157:H7 would exceed the inactivation

of *Salmonella* (U.S. Department of Agriculture, 2013a). Then, instructions for safe cooking of MTB were proposed by reference to a long established model for thermal inactivation of *Salmonella* (Goodfellow, & Brown, 1978). The proposed instructions were that items of MTB should be cooked to a temperature at the centre of 71.1 °C (160°F), or to 62.8 °C (145°F) with the item being held for 3 minutes before consumption (U.S. Department of Agriculture, 2013b).

The effects of cooking on *E. coli* O157:H7 in steaks prepared from beef primal cuts mechanically tenderized after their surfaces had been inoculated with large numbers of the pathogen have been investigated (Luchansky, Porto-Fett, Shoyer, Phebus, Thippareddi, & Call, 2009; Luchansky et al., 2012). In that study, when groups of steaks were cooked to temperatures at the centre between 49 °C and 71 °C, reductions in numbers of *E. coli* O157:H7 rarely exceeded 4 log units and generally varied by ≥ 2 log units. These results were ascribed to uneven heating of steaks with survival of the pathogen at persistent cold spots. Subsequent studies of the effects of cooking on *E. coli* O157:H7 inoculated at specific points within steaks confirmed that reductions in numbers of the pathogen at some points in some steaks were much less than 5 log units when steaks were cooked in accordance with the proposed instructions for safe cooking (Gill, Yang, Uttaro, & Liu, 2013; Gill, Devos, Youssef, & Yang, 2014).

Most culinary instructions for cooking steaks strongly recommend that steaks be turned over only once during grilling, broiling or frying (Beef Information Center, 2009; Meat and Livestock Australia, 2006; What's cooking America, 2012). To conform with this seemingly usual practice, much of the work on the effects of cooking on *E. coli* O157:H7 was carried out with steaks being turned over only once during cooking. When it became evident that less than 5 log reductions of *E. coli* O157:H7 in inoculated steaks cooked to relatively high temperatures in that manner was likely due to uneven heating of the meat, the possibility of obtaining consistently large reductions by turning steaks over more than once during cooking was investigated (Gill et al., 2013). The findings with that practice were that when steaks were turned over twice or more during cooking, at intervals appropriate for steak thickness, reduction in the numbers of *E. coli* O157:H7 > 5 log cfu at all inoculated points in steaks could be obtained consistently with cooking to ≥ 63 °C (Gill et al., 2014). Consequently, it was proposed that instruction for safe cooking of MTB steaks should stipulate not only the maximum temperature to be attained at steak centres but also that the steaks should be turned over more than once during cooking (Government of Canada, Department of Health, 2014). Such instructions would obviously contradict common culinary instructions, so compliance with the proposed instructions for safe cooking of MTB might involve substantial changes to the established steak cooking practices of many consumers. Therefore, for better understanding of how appropriate instructions for cooking MTB steaks to ensure their microbiological safety would be perceived and acted upon, a survey of Canadian consumers was conducted to ascertain current steak cooking practices and the likely responses to proposed safe cooking instructions on labels for MTB steaks.

2. Materials and Methods

A questionnaire to survey the steak cooking practices of Canadian consumers and their perceptions of instruction for safe cooking of MTB steaks was developed (Table 1). The first two questions (1, 2) were concerned with respondents' involvement in the cooking of beef and ownership of meat thermometers; five questions (3-7) were concerned with steak cooking practices; four (8-11) were concerned with awareness of and responses to information and instructions currently used with beef; and ten (12-21) were concerned with understanding and reaction to possible wording of instructions for safe cooking of MTB steaks. All questions were closed-ended, with the number of possible responses to individual questions ranging from 2 to 6.

The questionnaire was used in a telephone survey conducted by the Ipsos-Reid Corp. (Winnipeg, Manitoba, Canada) during September, 2013. The demographic characteristics of the respondents are shown in Table 2. The answers to questions 1 and 2 of all respondents in the initial group were considered. Respondents who indicated in question 2 that they were "almost never involved in preparation of beef" or "don't eat meat" were excluded from further questioning. For the four pairs of questions on understanding of specific wording of instructions and the likelihood of following the instructions (questions 12-19), the reduced group of respondents were split into two sub-groups. Respondents were assigned at random to one or other sub-group. The respondents in one sub-group were asked two of the pairs of questions (12, 13, 16 and 17), and the respondents in the other sub-group were asked the other two pairs of questions. This was done to reduce the lengths of interviews and so limit respondent and interviewer fatigue. All respondents in the reduced group were asked the final two questions, on alternative wording of instructions about the minimum degrees of cooking and the frequency of turning steaks over during cooking to ensure the microbiological safety of MTB steaks.

For estimations of consumer responses to the questions, the data were weighted to adjust the responses from each group or sub-group to take account of the current statistics for the gender, age, education, economic status and geographic distribution of the Canadian population. The weighted data are reported as estimated responses of Canadian consumers.

Table 1. Summarized versions of the questions asked in a survey of steak cooking practices and perceptions of instructions for safe cooking of mechanically tenderized steaks

No.	Question
1.	Do you own a meat thermometer?
2.	How often are you involved in the preparation of beef roasts or steaks?
3.	By which method do you cook steaks in spring and summer?
4.	By which method do you cook steaks in fall and winter?
5.	To what degree of doneness do you cook steaks?
6.	How many times do you turn over steaks during cooking?
7.	How often do you use a meat thermometer when cooking steaks?
8.	How often do you read labels on packs of raw beef?
9.	How often do you follow label instructions for safe handling and cooking?
10.	Have you noticed beef labelled as “mechanically tenderized”?
11.	Do you know what mechanically tenderized means?
12.	How easy is it to understand the instruction “Cook to a minimum temperature of 63°C throughout”?
13.	How likely would you be to follow the instruction in question 12?
14.	How easy is it to understand the instruction “Cook to a minimum temperature of 63°C (medium-rare)”?
15.	How likely would you be to follow the instructions in question 14?
16.	How easy is it to understand the instructions “Cook to a minimum internal temperature of 63°C (medium rare) and flip steaks at least twice while cooking”?
17.	How likely would you be to follow the instructions in question 16?
18.	How easy is it to understand the instructions “Cook to a minimum internal temperature of 63°C (medium-rare) and flip steaks every 2 minutes while cooking”?
19.	How likely would you be to follow the instructions in question 18?
20.	Of the two instructions “Cook to 63°C throughout” or “Cook to 63°C throughout (medium-rare)” which would you be more likely to follow?
21.	Of the two instructions “Flip steaks at least twice during cooking” or “Flip steaks every two minutes during cooking” which would you be more likely to follow?

Table 2. Demographic characteristics of the respondents in the groups and sub-groups that answered the questionnaire

Characteristic		Number of respondents (%)			
		Initial group (n=1021)	Reduced group (n=915)	Divided reduced group	
				Sub-group 1 (n=458)	Sub-group 2 (n=457)
Gender:	Male	437 (43)	393 (43)	190 (41)	203 (44)
	Female	584 (57)	522 (57)	268 (59)	254 (56)
Age:	18-34 years	205 (20)	163 (18)	86 (19)	77 (17)
	35-54 years	431 (42)	437 (43)	198 (43)	201 (44)
	≥55 years	385 (38)	437 (43)	174 (38)	179 (39)
Education:	No HS ^a certificate	68 (7)	62 (7)	34 (7)	28 (6)
	HS certificate	245 (24)	223 (24)	108 (24)	115 (25)
	PS ^b qualification, non-degree	454 (44)	404 (44)	199 (43)	205 (45)
	University degree	254 (25)	226 (25)	117 (26)	109 (24)
Household annual income:	<\$40K	280 (27)	245 (27)	135 (29)	110 (24)
	\$40K-\$60K	185 (18)	169 (18)	78 (17)	91 (20)
	\$60K-\$100K	267 (26)	241 (26)	112 (24)	129 (28)
	>\$100K	149 (15)	137 (15)	70 (15)	67 (15)
	No response	140 (14)	123 (13)	63 (14)	60 (13)
Domicile:	British Columbia	134 (13)	125 (14)	61 (13)	64 (14)
	Prairie provinces ^c	174 (17)	152 (17)	90 (20)	62 (14)
	Ontario	363 (36)	322 (35)	155 (34)	167 (37)
	Quebec	267 (26)	238 (26)	115 (25)	123 (27)
	Atlantic provinces ^d	83 (8)	78 (9)	37 (8)	41 (9)

^a HS; high school certificate

^b PS; post-secondary

^c Prairie provinces; Alberta, Saskatchewan, Manitoba

^d Atlantic provinces; New Brunswick, Nova Scotia, Prince Edward Island, Newfoundland and Labrador.

Table 3. Canadian consumers preferred methods of cooking beef steaks in the spring and summer or fall and winter

Cooking method	Fraction of consumers (%)	
	Spring/summer	Fall/winter
Barbecue grill	69	34
Pan frying or broiling	17	35
Oven broiling	9	23
Indoor grill	4	7
Other	0	1
No preference	1	1

Table 4. The proportions of occasions on which Canadian consumers prepare beef steaks that they read the label on the retail package and follow label instructions for safe cooking of meat

Proportion of occasions	Fractions of consumers (%)	
	Who read the label	Who follow the instructions
Almost always	31	31
Most times	26	33
About half the times	13	14
Rarely	13	13
Almost never	11	8
Don't know	1	2

Table 5. Canadian consumers ease of understanding of proposed instructions for safe cooking of mechanically tenderized beef steaks

Ease of understanding	Fraction of consumers (%)			
	Instruction 1 ^a	Instruction 2 ^b	Instruction 3 ^c	Instruction 4 ^d
Very easy	67	64	66	70
Somewhat easy	18	25	24	18
Neither easy nor difficult	7	6	7	7
Somewhat difficult	4	3	2	2
Very difficult	1	1	1	1
Don't know	3	1	1	2

^a Instruction 1, "Cook to a minimum temperature of 63°C throughout."

^b Instruction 2, "Cook to a minimum temperature of 63°C throughout (medium-rare)."

^c Instruction 3, "Cook to a minimum internal temperature of 63°C throughout (medium-rare) and flip at least twice during cooking."

^d Instruction 4, "Cook to a minimum internal temperature of 63°C throughout (medium-rare) and flip every two minutes while cooking."

Table 6. Likelihood of Canadian consumers following proposed instructions for safe cooking of mechanically tenderized steaks

Likelihood of following instructions	Fraction of consumers (%)			
	Instruction 1 ^a	Instruction 2 ^b	Instruction 3 ^c	Instruction 4 ^d
Very likely	48	54	54	46
Somewhat likely	33	31	35	31
Somewhat unlikely	12	10	7	14
Very unlikely	7	4	4	10

^a Instruction 1, "Cook to a minimum temperature of 63°C throughout."

^b Instruction 2, "Cook to a minimum temperature of 63°C throughout (medium-rare)."

^c Instruction 3, "Cook to a minimum internal temperature of 63°C throughout (medium-rare) and flip at least twice during cooking."

^d Instruction 4, "Cook to a minimum internal temperature of 63°C throughout (medium-rare) and flip every two minutes while cooking."

3. Results

The initial number of respondents was 1021. The responses of this group indicated that 52% of Canadian consumers own a meat thermometer; but 9% are rarely involved in the preparation of beef while 2% do not eat meat.

After exclusion of the respondents who considered that they are rarely involved in the preparation of beef or do not eat meat, 915 respondents remained. The responses of this reduced group indicated a strong consumer preference for cooking steaks on a barbecue grill during spring and summer, but with pan frying or broiling and oven broiling being preferred in the fall and winter (Table 3). The responses indicated that 95% of consumers prefer steaks cooked to a medium rare or more well done condition (well done, 18%; medium well done, 29%; medium, 22%; medium rare, 26%). The fraction of consumers indicated as turning steaks over two or more times during cooking was 66% (once, 28%; twice, 35%; three or more times, 31%; don't know, 5%). The fraction of consumers using a thermometer to measure steak temperatures on half or more of the occasions they cook steaks was indicated to be 19% (always, 6%; usually, 6%; half the time, 7%; rarely, 19%; never, 57%; don't know, 4%).

The responses of the reduced group indicated that 70% of consumers read labels on retail packs of beef steaks on about half or more of the occasions that they cook steaks (Table 4). Despite that, the responses of the group indicated that 78% of consumers follow instructions for safe cooking of the meat on pack labels on half or more of the occasions they cook steaks. The responses indicated that only 16% of consumers will have noticed labels that identify beef as having been mechanically tenderized; but that 38% of consumers believe they know what is meant by the term "mechanically tenderized."

The reduced group of respondents was divided into two sub-groups, of 458 and 457 respondents, for consideration of proposed label instructions for safe cooking of mechanically tenderized steaks. The responses of these groups indicated that over 80% of consumers would find all four of the proposed instructions somewhat or very easy to understand (Table 5); and that over 80% of consumers would be somewhat or very likely to follow three of the proposed instructions (Table 6). However, less than 80% would be somewhat or very likely to follow an instruction to "flip steaks every two minutes while cooking".

The responses of the whole reduced group to the question about which of the instructions "Cook to a minimum temperature of 63 °C throughout" or "Cook to a minimum temperature of 63 °C throughout (medium rare)" would more likely be followed indicated that 56% of consumers would be equally likely to follow either instruction, but that 12% would be more likely to follow the first and 32% more likely to follow the second instruction. The responses to the same question about the pair of instructions "Flip at least twice during cooking" and "Flip every two minutes while cooking" indicated that 40% of consumers would be likely to follow either instruction, but that 42% would be more likely to follow the first and 18% more likely to follow the second instruction.

4. Discussion

It has long been recognized that, for consumer safety, meats should be cooked to temperatures that will ensure inactivation of all enteric pathogens that may be present in the meat. A cooked appearance of muscle tissue does not provide reliable indication of the tissue experiencing heating sufficient for ensuring microbiological safety (Lyon, Berry, Soderberg, & Clinch, 2000). Therefore, North American regulatory authorities, consumer advocacy groups and meat or retail industry organizations instigated various campaigns to promote consumers' use of meat thermometers during cooking of hamburger patties and other forms of meat posing comparable microbiological risks (Takeuchi, Hillers, Edwards, Edlefsen, & McCurdy, 2005). Such campaigns have probably been a factor in increased household ownership of food thermometers in recent years (Lando, & Chen, 2012).

Even so, the extent to which meat thermometers are used to check the temperatures of cooking steaks is uncertain. Data on consumers' use of meat thermometers with steaks are lacking, but in a recent survey of U.S. consumers the use of meat thermometers with hamburger patties was estimated to be only 16%. Moreover, consumers' perceptions of their usage of meat thermometers may be exaggerated, as consumers have been found in practice to use thermometers with hamburger patties less often than they claim (Phang, & Bruhn, 2011). In view of the findings for hamburger patties it seems likely that most North American consumers do not use a meat thermometer to check the temperature attained in cooked beef steaks, and so rely on meat appearance to assess the degree to which steaks are cooked.

Vegetarians were previously reported to be 4% of the Canadian population (American Dietetic Association & Dieticians of Canada, 2003), while the fraction of vegetarians among U.S. consumers has apparently greatly

increased in recent years (Jensen, 2013; Newport, 2012). The proportion of the population who engage in cooking has declined (Smith, Ng, & Popkin, 2013). Trends in Canada and the USA likely are similar. Thus, it is possible that non-meat eaters and those who do not engage in cooking were under represented in the initial group of respondents. However, this would not be expected to affect the composition of the group of respondents from which they were excluded.

The findings of our survey indicate that cooking steaks on a barbecue grill is preferred by a majority of Canadian consumers in spring and summer, but in the often harsh fall and winter months, cooking indoors is more usual. Barbecue grill cooking of steaks apparently is also favoured by many or most consumers elsewhere in North America (McKenna et al., 2004; Mueller, King, Baird, McKenna, Oshum, & Savell, 2006). As the intensity of thermal treatment characterizing each cooking method has impact on pathogen reduction (Shen, Adler, Geornaras, Belk, Smith, & Sofos, 2010), information on preferred cooking methods can be used for assessing risks associated with consumption of MTB.

The great majority of Canadian consumers evidently prefer beef steaks to be cooked to a medium rare or more well done condition. Surveys of U.S. and Australian consumers have similarly found greater than 95% preferences for medium rare or more well done steaks (Cox, Thompson, Cunial, Winter, & Gordon, 1997; McKenna et al., 2004; Reicks, Brooks, Garmyn, Thompson, Lyford, & Miller, 2011). The American Meat Science Association (1995) categorized steaks that had been cooked to 63 °C as medium rare. It is widely assumed that this relationship between cooked to temperature and consumer assessment of the degree of doneness has broad application. It appears, however, that many consumers who express a preference for medium rare steaks in fact prefer meat that is cooked to > 63 °C (Lopez Osornio, Hough, Salvador, Chambers IV, McGraw, & Fiszman, 2008). The findings of our survey show that the majority of Canadian consumers turn steaks over more than once during cooking, and so preferably employ procedures that will ensure the safety of MTB steaks. Information on steak cooking procedures of consumers elsewhere is lacking, but it seems likely that turning steaks over more than once is the usual practice of many consumers.

The findings of our survey indicate that few Canadian consumers would have difficulty understanding the proposed instructions for safe cooking of MTB steaks; and that most would be inclined to follow those instructions. The latter finding is agreeable with the findings of a U.S. survey in which a large minority of consumers indicated they had changed their food preparation practices in response to safe handling instructions on packs of raw meat (Yang, Angulo, & Altekruze, 2000). However, as with hamburger patties, it is not obvious how the majority of consumers could be sure of cooking meat to or above a specified temperature without use of a meat thermometer. Evidently, a general instruction to turn MTB steaks over more than once during cooking is more likely to be followed by consumers than an instruction stipulating turning over of steaks at precise intervals.

5. Conclusions

This survey provides very useful information on current practices of Canadian consumers for cooking beef steaks in relation to ensuring the microbiological safety of such meat and on the likelihood of Canadian consumers to follow proposed cooking procedures intended for labels on packs of MTB. Therefore, labeling of packs of MTB steaks with appropriate recommendations for safe cooking could be expected to promote wide adoption by Canadian consumers of safe practices for cooking such meat.

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