THE INFLUENCE OF POST-COOKING HOLDING TIME ON THE SENSORY ATTRIBUTES OF TRADITIONAL OR SUSPENTEC® ENHANCED FLAT IRON STEAKS

By

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IRON STEAKS

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TABLE OF CONTENTS

CHAPTER I

INTRODUCTION

With the chuck representing approximately one-quarter of the weight of a beef carcass, there is a need to improve these cuts of meat that have traditionally been marketed as low-priced steaks and roasts. In recent years, the beef industry has concentrated on "value-added" beef by researching the individual characteristics of the muscles within the beef chuck. Driven by economic incentive to improve the value of a beef carcass, many underutilized cuts that were traditionally ground or sold as low-priced cuts of meat are now being successfully marketed and sold as palatable, single muscle steaks. While improvements are continuously being made, some characteristics of these improved cuts create other challenges. Factors such as muscle location and function, tenderness, connective tissue content, or development of off-flavor result in certain issues that need to be addressed and improved in order to ensure the consumer a pleasant eating experience, resulting in repeat purchase and consumption.

CHAPTER II

REVIEW OF LITERATURE

Importance of Beef Tenderness

Tenderness has been identified as the most important palatability attribute of meat and thus, the primary determinant of meat quality (Huffman et al., 1996). Tenderness is also the most important factor influencing consumer satisfaction for beef palatability (Savell et al., 1987, 1989; Smith et al., 1987). According to Miller et al. (2001), practical WBSF values for tender, slightly tender/slightly tough, and tough are < 3.0, 3.0-4.6, and > 4.6 kg, respectively. The Beef Customer Satisfaction Study (Neely et al., 1998; Lorenzen et al., 1999; Savell et al., 1999) identified tenderness as a major and contributing factor to consumers' perception of taste. In a study by Huffman et al. (1996), consumers were asked to rank different quality traits and 51% ranked tenderness as the number one trait. Boleman et al. (1997) suggested that consumers were not only capable of discerning different categories of tenderness, but were willing to pay more for guaranteed tender beef products. As a result of the higher price of beef compared to other protein sources, the importance of a good eating experience is crucial to maintaining or improving current beef buying trends.

Variation in Tenderness

Many factors contribute to the variability of tenderness within a beef carcass. Rueter et al. (2005) stated that tenderness is a characteristic that has large variation among animals, carcasses, muscles, and cuts of meat. Muscles from the chuck have shown to be less tender as a result of collagen content, connective tissue content, muscle fiber classification, and function. Johnson et al. (1988) reported that total collagen content present within a muscle is positively correlated with Warner Bratzler Shear Force (WBSF) values for that particular muscle. It has also been reported that there is a relationship between meat quality and muscle fiber-type composition (Cassens and Cooper, 1971; Ashmore, 1974; Seideman and Theer, 1986). Kirchofer et al. (2002) determined that muscles in the beef chuck have extensive variation in fiber types. Muscles with increased α-white fibers have more connective tissue, less intramuscular fat, and are less tender than muscles with more β-red fibers (Melton et al., 1974, 1975; Calkins et al., 1981).

Tenderness of various beef chuck muscles

The size, shape, and composition of the muscles in the beef chuck vary greatly. Studies by Paterson and Parish (1986), Johnson et al. (1988), and NCBA (2000) have been conducted to determine the physical and chemical composition of muscles from the beef chuck to gain a better understanding of their eating potential. As a result of the various sizes and shapes of chuck muscles, measuring tenderness of a single steak may not adequately represent the entire muscle, for it is possible for different regions of a muscle to have different tenderness ratings. The most tender of the muscles in the beef chuck are classified as β-red muscle fibers or intermediate muscle fibers and include muscles such as the *Supraspinatus* (SS), *Infraspinatus* (IF), *Triceps Brachii* (TB), and *Serratus Ventralis* (SV).

Searls et al. (2005) evaluated these four muscles of the chuck to determine intramuscular tenderness variation within each of these muscles. The SS was classified as tough with a mean shear force of 5.43 kg, ruling it unsuitable to be marketed as a single steak (Searls et al., 2005). The IF was the only muscle of the four evaluated found to be consistently tender (average steak shear of 3.16 kg), with no significant differences in WBSF throughout the entire muscle (Searls et al., 2005). For these reasons, the IF was the only muscle evaluated capable of being marketed as a single steak. The TB received a mean shear force of 4.12 kg with consistent varying degrees of tenderness (Searls et al., 2005). The distal end of the TB was unacceptable for tenderness, whereas the proximal ends were ruled acceptable for tenderness (Searls et al., 2005). There were differences in tenderness values within the SV, but there was no consistent pattern (Searls et al., 2005). In addition, previous studies by Patterson and Parish (1986) evaluated nine muscles from the chuck and reported that the IF scored highest in sensory panel scores for tenderness and overall palatability.

One explanation for the consistency in tenderness for the IF may be muscle function and collagen content. Since the IF is used primarily to rotate the arm of an animal outward, it serves no substantial locomotive action. In addition, Jones et al. (2000) discovered that the IF contains a collagen content of approximately 8.72 mg/g, which is considerably less than the SS which is considered to be tough with a collagen content of 17.77 mg/g. Total collagen present in a muscle is positively correlated with its WBSF values (Johnson et al., 1988). High levels of collagen greatly affect WBSF values because muscle fiber networks become more durable as they connect to collagen (Searls et al., 2005).

<u>Tenderness threshold levels of beef value cuts</u>

With so much variation found within the muscles of a beef carcass, it is probable that different tenderness threshold values and levels of acceptability exist for different muscles. Determining tenderness threshold values for the beef value cuts will allow the beef industry to segment cuts according to tenderness classifications. This segmentation will allow the beef industry to reduce the variation in beef tenderness and charge a premium for more tender beef. With the ability to purchase beef according to tenderness, consumers are more likely to have a positive eating experience that will increase satisfaction and demand.

Shackelford et al. (1991) established tenderness threshold levels of satisfaction for WBSF of beef top loin steaks. The resulting WBSF thresholds were 4.6 kg, 3.9 kg, and 3.2 kg with confidence levels of 50, 68, and 95%, respectively (Shackelford et al. 1991). When compared to data from the National Consumer Retail Beef Study (Savell et al., 1987), the 50% and 68% confidence levels were approximately 90 and 74% accurate in predicting a steak to be rated “slightly tender” or less. These threshold values are considered to be benchmark values and have been used in studies to categorize steaks into tenderness categories according to their WBSF values (Belew et al., 2003; Brooks et al., 2000; Morgan et al., 1991; Voges et al. 2006).

Sitka et al. (2007) attempted to identify threshold levels for WBSF of beef value cuts. It was found that individual consumer preference made it difficult to specify one WBSF value that satisfies all consumers. Sensory attributes such as flavor and juiciness influence overall acceptability to panelists. After a certain level of tenderness has been reached, other sensory attributes may become more crucial in determining overall acceptability in beef cuts. For the IF, all simple correlation coefficients of consumer sensory attributes were significant and juiciness, tenderness, flavor level, level of tenderness, and level of juiciness displayed high correlations within overall like with values of 0.69, 0.67, 0.64, 0.55, and 0.48, respectively (Sitka et al., 2007). Establishing values associated with varying degrees of beef tenderness along with tenderness thresholds will provide the economic incentive for the beef industry to manage, and market tenderness to consumers (Miller et al., 2001).

Marketing muscles of the beef chuck

Traditionally, the beef chuck has been merchandised in the form of low-priced steaks and roasts consisting of different muscles and varying quantities of intramuscular fat (Kukowski, 2003). The high degree of variability and palatability characteristics of muscles of the forequarter make marketing difficult and decreases sales (Johnson et al., 1988). Marketing of the forequarter is further complicated with the chuck representing approximately 25% of the total volume of a carcass.

From an economic perspective, it was obvious that considerable value was lost in the majority of meat from beef carcasses. The need to increase the value of the beef chuck by increasing the use of smaller muscles into value-added products using further processing techniques was addressed by the NCBA along with the Cattlemen's Beef Board. Together a research initiative was established to explore ways to add value to the chuck (NCBA, 2000). One proposed method for increasing the value of the chuck was to develop innovative fabrication techniques, called the Beef Value Cuts program, to merchandize individual muscles from those primals and subprimals. This program was designed to increase the total cutout value of beef carcasses by increasing the value of each of the individual components, resulting in a significant cumulative increase in the value of the chuck (McKenna et al., 2003).

This loss of value of the beef chuck led to the development of the muscle profiling project, which characterized the physical, chemical, sensory, and processing characteristics of muscles from the chuck (Von Seggern et al., 2005).
Muscle profiling was conducted to determine the precise characterization of muscles by physical and chemical analysis and developing improved understanding of properties of individual muscles to better utilize them. Muscle profiling was primarily studied to better understand the characterization of the under-utilized cuts of beef (Meisinger et al., 2006).

Von Seggern et al. (2005) conducted a muscle profiling study in which 142 carcasses and over 5000 muscles were sampled. Objective color, expressible moisture, emulsion capacity, pH, proximate composition, total collagen content, and total heme-iron concentration were analyzed for the study. Variation was observed in all the above traits and it was generally found that quality grade most often had an effect, with weight and yield grade having fewer effects (Von Seggern et al., 2005). This research enabled decisions to be made in the selection of muscles from the beef chuck for the production of value added products (Von Seggern et al., 2005).

As a result of the research conducted by Von Seggern et al. (2005), the wholesale value of the beef chuck has risen significantly and consumer demand has increased the value of a beef carcass. This research also led to the development and application of value-added technology (Von Seggern et al., 2005). In addition, it is suggested that results from this research has assisted in adding $50 – 70 per head to market steers and heifers in the United States (Von Seggern et al., 2005). Also, James and Calkins (2008) stated that the value for the beef carcass has increased by approximately $33/100 kg as a result of previous research, supply, and marketing. As much as $13.23/100 kg has been attributed to the fabrication of steaks from individual muscles from the beef chuck (Ishmael, 2004).

Flat Iron Steak

Given the ideal timing paired with the economic incentive driving implementation of the Beef Value Cuts program, the success of the "flat iron" steak (IF muscle) was developed shortly after release of the muscle profiling data (Von Seggern et al., 2005). The IF is uniquely fabricated in such a way that the internal connective tissue seam is removed, greatly improving tenderness and consistency, enabling this muscle to be marketed as a single steak (Von Seggern et al., 2005). According to NCBA, the flat iron steak has taken off in popularity throughout the United States in recent years. In 2005, foodservice volume of the flat iron steak was approximately 47 million pounds and in 2007, volume nearly doubled to 90 million pounds and these numbers are expected to continue to increase (NCBA, 2010).

Off-Flavors

In recent years, the foodservice industry has begun to use various steaks obtained from the beef chuck. In addition to the IF (flat iron), other steaks used in foodservice include the TM (shoulder tender), TB (clod heart), and *serratus ventalis,* SV (Denver cut). Managers in the foodservice industry have reported an increasing number of complaints from customers concerning off-flavors in some of the beef value cuts. Some of the various off-flavors are described as liver-like, metallic, fatty, and sour (James and Calkins, 2008). In foodservice, meat is cooked and then traditionally held for a period of time prior to serving. Most of the common cuts of beef (prime rib, ribeye, or sirloin steaks) are typically able to withstand the holding period. With the less expensive beef value cuts being offered as substitutes for the primary meat entrees, the impact of post-cooking holding time on palatability characteristics needs to be addressed in order to ensure that consumers have a positive eating experience and are willing to purchase and consume the product again.

The influence of cooking rate and post-cooking holding time on palatability characteristics was evaluated by James and Calkins (2008). Numerous studies have identified that the IF was the most tender muscle in the beef chuck as evaluated by both WBSF measurement and through sensory evaluations (Calkins, 2002a, 2002b; Elam et al., 2002a, 2002b; Meisinger et al., 2006), and James and Calkins (2008) demonstrated this again. The IF was rated as having the least amount of connective tissue content of the muscles evaluated when held for one hour (James and Calkins, 2008). In addition, the IF had no differences due to cooking rate for juiciness and was not significantly different for cooking rate and holding time treatments (James and Calkins, 2008). The IF had lower percentages of panelists indicating the samples having an oxidized off-flavor (James and Calkins, 2008). Overall, the IF was found to have the highest response of no off-flavors being detected in the samples tested (James and Calkins, 2008).

Sensory attributes such as beef flavor, tenderness, and juiciness can be improved through injecting beef with enhancement solutions. Several studies have shown that injecting beef with solutions of salt, sodium tripolyphosphate, and sodium lactate enhances cooked beef flavor (Papadopoulos et al., 1991a, b; Lamkey et al., 1993) in addition to improving tenderness (Papadopoulos et al., 1991b). In addition, Vote et al. (2000) showed that beef loin steaks injected with phosphate/lactate/chloride solutions had a tendency to receive higher cooked beef flavor than untreated control steaks.

Enhancing palatability of beef chuck muscles

Injection with a salt/phosphate solution has shown to increase water binding capacity and tenderness (Vote et al., 2000; Lawrence et al., 2004; Baublits et al., 2006). The chloride ions of salt are thought to bind to the myofilaments and increase the electrostatic repulsive force between them (Offer and Trinick, 1983), allowing more water to fill the space and be held by capillary forces. Hamling and Calkins (2008) injected three muscles from the beef chuck (TB, biceps femoris, (BF) and RF) with four pump levels (0%, 15%, 22.5%, and 30%) containing a solution of water, salt, ammonium hydroxide, and carbon monoxide. It was found through trained sensory evaluation that there was an increase in tenderness, decrease in connective tissue, and an increase in juiciness as pump level increased for all muscles evaluated (Hamling and Calkins, 2008). Although muscles injected to 30% received the highest scores for tenderness, connective tissue content, juiciness, and flavor, panelists noted that there was an uncharacteristic soft and mushy, non-meat texture associated with the evaluated muscles (Hamling and Calkins, 2008). Based on the results, the optimum pump level for all evaluated muscles was determined to be approximately 20%, for there were no significant differences between the 15% and 22.5% injections (Hamling and Calkins, 2008). Any injection percentage was shown to be an improvement over the control treatments for tenderness and juiciness (Hamling and Calkins, 2008).

SuspenTec®

Traditional enhancement procedures have successfully been shown to improve palatability characteristics of beef steaks. In recent years, the pork industry has begun to use a more advanced procedure involving the injection of 50/50 trim back into pork products. This patented process is developed by Cozzini (Cozzini, Inc., Chicago, IL) and is known as the SuspenTec® system. This technology uses traditional enhancement techniques with the concept of emulsion technologies to incorporate 50/50 trim into a suspension within a traditional brine solution. This technology is now used all over the world to process roast beef, ham, poultry products, steak, fish, bacon, and other whole muscle products. The SuspenTec® system increases value to food products while lowering the costs of finished goods. The system incorporates the injection of lower cost proteins into higher cost whole muscle products which enhance binding ability, reduce cook and chill shrink loss, and increase product yield.

This suspension consists of a brine solution with pre-ground 50/50 trim added to achieve a homogeneous mixture. Once the mixture is attained, the brine is pumped to the particle reducing mill to reduce the protein to micron size particles and then incorporates them with the brine solution, forming a suspension. The appropriate particle size is achieved after approximately 3 min of milling and the suspension is diverted to the suspension holding hopper that feeds the injector. Whole muscle product is then injected with the suspension to the preset yield gain. This technology is now being used more extensively to provide a more tender, juicy product that increases product consistency and also adds overall yield to the product, increasing profitability.

Summary and Conclusions from the Literature

In summary, much progress has been made to increase the value of a beef carcass through better implementation of underutilized cuts of meat. From these once underutilized cuts, have arose great success in value added improvement and more importantly, new opportunities to further improve quality and palatability, and also to address certain issues in order to maintain and ensure a pleasant eating experience by all consumers, enabling continued purchase and consumption.

This study was designed to investigate the relationship between palatability characteristics and post-cooking holding time of flat iron steaks injected with two different enhancements. The enhancements used in this study were a traditional 10% brine and a 30% SuspenTec® suspension. The palatability characteristics of juiciness, tenderness, connective tissue content, cooked beef flavor, and the off-flavors of painty/fishy and livery/metallic of flat iron steaks were evaluated across holding times of 0, 30, and 60 minutes post-cooking.

CHAPTER III

THE INFLUENCE OF POST-COOKING HOLDING TIME ON THE SENSORY ATTRIBUTES OF TRADITIONAL OR SUSPENTEC® ENHANCED FLAT IRON STEAKS

Abstract

The objective of the study was to evaluate the influence of post-cooking holding time on sensory attributes of flat iron steaks injected with one of two different enhancements or a control. Treatments consisted of a control (CONT), 10% traditional enhancement (E), or a 30% SuspenTec® suspension (patented technology developed by Cozzini technologies, Chicago, IL) technology (SUSP). Flat iron steaks (n = 162) were equally allotted to each treatment, yielding 54 steaks to be used for each. Steaks were enhanced according to their respective treatments, individually vacuum packaged and frozen. Warner-Bratzler shear force, TBARS analysis, and sensory evaluation were determined. Shear force was highest for the CONT and the enhancement treatments were not different from each other ($P < 0.05$). The TBARS analysis displayed SUSP to have the least amount of lipid oxidization of the treatments due to the presence on an antioxidant, whereas CONT contained the highest amount of oxidation ($P < 0.0010$). The SUSP treatment was significantly higher in preferred cooked beef flavor at holding time 0 min and displayed highest numerical scores during the remaining holding times. The

SUSP treatment was the preferred treatment for lowest incidence of livery/metallic off-flavor ($P > 0.05$) at holding times 0 and 30 min. No differences were observed for painty/fishy off-flavor at holding times 0 and 30 min for any treatment. At holding time 60 min, SUSP showed a tendency to have the least detection of painty/fishy off-flavor ($P < 0.10$). The SUSP treatment was the saltiest treatment evaluated ($P < 0.0007$). The SUSP was the most tender across holding times of 30 and 60 min ($P < 0.05$) and also showed a tendency to be most tender at time 0 ($P < 0.10$). The SUSP was also the juiciness treatment across all holding times ($P < 0.05$). In addition to being superior in overall tenderness and juiciness, the SUSP was the most effective treatment analyzed for sensory characteristics across holding times with the exception of 3 areas (painty/fishy at 30 min, livery/metallic at 60 min and cooked beef flavor at 30 min), in which the values were the same as at least one other treatment. Data showed that both enhancement treatments were superior to the CONT in terms of sensory characteristics across all holding times. Additionally, data suggests the tendency for SUSP to outperform E throughout the majority of sensory evaluations in cooked flat iron steaks.

Key Words**:** Flat iron steak, Off-flavors, Sensory, Holding time, Enhancement, SuspenTec

Introduction

The beef chuck has generally been merchandized as low-priced roasts and steaks consisting of various muscles (Kukowski, 2003). Since 1998, the value of the beef carcass has increased nearly $33/100 kg due to research and marketing campaigns

(Ishmael, 2004). As much as $13.23/100 kg of the $33/100 kg has been attributed to the fabrication of steaks from individual chuck muscles (Ishmael, 2004). Due to the need to increase revenue of beef chuck cuts, researchers began evaluating characteristics of chuck muscles to better understand their eating potential. This intensive work of characterizing individual chuck muscles is known as muscle profiling and is one of the greatest enhancements of value to the beef carcass beyond the use of further processing in fresh meat. Muscle profiling identified several muscles that could be redirected from use in ground or processed product and are instead marketed as fresh cuts with desirable eating characteristics and enhanced value (VonSeggern et al., 2005). Muscle profiling resulted in the development of the flat iron steak from the IF at the University of Florida by Dr. Dwain Johnson in cooperation with the University of Nebraska and the National Cattleman's Beef Association (NCBA). According to NCBA, 2007 foodservice volume of the flat iron steak was 40.8 million kg and figures are expected to increase (NCBA, 2010).

Off-flavor issues arose with the popularity of the flat iron steak in the restaurant. Meat is typically held prior to being served in the food industry and this holding period may increase the incidence of off-flavors. With the flat iron steak gaining popularity in the restaurant, attention should be directed towards off-flavor issues associated with holding times to ensure a positive eating experience. Therefore, the objective of this study was to evaluate the influence of post-cooking holding time on sensory attributes of flat iron steaks injected with a traditional 10% brine or a 30% SuspenTec® suspension.

Materials and Methods

Flat Iron Steaks

Flat Iron steaks (n = 162) were obtained from National Beef Company in Liberal, KS and delivered to the Robert M. Kerr Food and Agricultural Products Research and Technology Center (FAPC) at Oklahoma State University, Stillwater. Steaks were allotted to either a control group (CONT), a traditional 10% enhancement group (E), or a 30% SuspenTec® suspension group (SUSP) developed by Cozzini Technologies (Chicago, IL). The green weights were recorded for each group prior to injection to determine overall injection percentages after the enhancement process. One third (n = 54) were used as CONT with no enhancement procedures, one third were injected with the 30% SUSP and the remaining one third were injected with the E using a Fomaco injector (Resier Canton, MA).

SuspenTec®

The SuspenTec ® technology (Cozzini, Inc., Chicago, IL) uses traditional enhancement techniques with the concept of emulsion technologies to incorporate 50/50 beef trimmings into a suspension within a traditional brine solution. Hayden et al. (2010) found that the 30% SUSP solution was the most effective injection level that was analyzed for round cuts. The 30% SUSP solution contains 30% of the suspension in the form of 50/50 beef trimmings with the remaining percentage being the pre-formulated brine solution. The targeted injection percentage for the SUSP solution was 18%. The suspension consisted of 94.9 kg of brine solution in addition to 41.17 kg of 8mm pre-ground 50/50 trim added to achieve a homogeneous mixture. Once the mixture was attained, the brine was pumped to the particle reducing mill to reduce meat to micron size particles and incorporate them with the brine solution, forming a suspension. The appropriate particle size was achieved after 3 min of milling and the suspension was diverted to the suspension holding hopper that feeds the injector. After the temperature of the suspension reached -2.2°C, flat iron steaks were injected using a Fomaco injector (Reiser; Canton, MA) at 57 psi and 22 strokes/min. After the injection, the product was vacuum tumbled for 15 min under 25-30 psi, re-weighed to determine the percent injection of 10.77%, individually vacuum packaged, and frozen in a blast freezer (-30° ± 10°C) until further analysis.

Traditional Enhancement

An enhancement that best represented the industry standard was used. The E contained water (67.2%), sodium phosphate (5.265%), salt (4.860%), Vivox4 as an antioxidant (0.675%), Purasal P (20.250%) and Proliant B1301 beef stock (1.755%). Targeted total injection was approximately 10%. The brine solution was mixed and blended 2 h prior to injection to acquire a final temperature of 3.3°C prior to injection. The brine was mixed beginning with phosphate followed by the addition of salt and blended until both were dissolved and the other ingredients were added until a homogenous mixture was achieved. The product was then injected, tumbled, packaged, and frozen as described above for SUSP. The final injection percentage for the E steaks was 3.22%, much less than the expected 10%. The actual injection percentage can be explained by the flat iron steaks being too thin to accept and retain the desired pump level of the brine.

Warner-Bratzler Shear Force Analysis

Warner-Bratzler shear force (WBSF) was completed using the American Meat Science Association (AMSA) guidelines (1995). Frozen steaks were allowed to temper at 2° ± 2°C for 24 h prior to cooking. Steaks were broiled on an impingement oven (XLT Impinger, Model 3240-TS, BOFI Inc., Wichita, KS) at 190.56ºC to an internal temperature of 65ºC, achieving a medium-rare degree of doneness. An Atkins AccuTuff 340 thermometer (Atkins Temtec, Gainesville, FL) was used to measure the temperature of each steak as it exited the oven. Steaks were placed on trays and covered and then cooled at 2º ± 2°C for 18 to 24 h. Six cores, 1.27 cm in diameter, were removed parallel to muscle fiber orientation and sheared once perpendicular to the muscle fibers, using a Warner-Bratzler head attached to an Instron Universal Testing Machine (Model 4502, Instron Corporation, Canton, MS). The Warner-Bratzler head moved at a crosshead speed of 200 mm/min. Peak load (kg) of each core was recorded by an IBM PS2 (Model 55 SX) using software provided by the Instron Corporation. Peak load (kg) for all six cores was averaged and mean peak load (kg) was analyzed for each sample. Since steaks were cooked to their appropriate temperatures and then allowed to cool for 18-24 hr, shear force was not measured across holding times.

Sensory Analysis

Flat iron steaks used for sensory evaluation were allowed to temper for 24 h prior to each session and were then cut into thirds for each specified holding period of 0, 30, and 60 min prior to being cooked as described above for WBSF analysis. Steaks with a 0 min holding time were immediately cut into 1.27 x 1.27 x 1.27 cm cubes (sample size was limited based on the size of the flat iron steaks after they were cut into thirds for the specified holding times) after being cooked and placed in a cup with the corresponding randomized number and served to the panelists. Steaks that were to be used for the 30 and 60 min holding time analysis were pulled form the oven after reaching the appropriate internal temperature and immediately placed into corresponding plastic bags and placed into a warmer (Food Warming Equipment, Model PS-1220-15, Crystal Lake, IL) during their holding times prior to being cubed and served to the panelists. The sensory panel consisted of six trained OSU personnel. Panelists were trained on tenderness, juiciness, and four specific flavor attributes (Cross et al., 1978). Sensory sessions were conducted twice a day and each session contained 12 samples. Samples were evaluated using a standard ballot from the AMSA (AMSA, 1995). The ballot consisted of a numerical, eight-point scale for initial and sustained juiciness (8 = extremely juicy, 1 = extremely dry), initial and overall tenderness (8 = extremely tender, 1 = extremely tough), and connective tissue amount (8 = none, 1 = abundant). The flavor attributes of beef, painty/fishy, and livery/metallic were evaluated using a three-point scale (1 = not detectable, 2 = slightly detectable, 3 = strongly detectable). Flavor attributes for saltiness were evaluated using a fifteen point scale (15 = extreme saltiness, 1 = no detection of saltiness). During sessions, panelists were randomly seated in individual booths in a temperature controlled room with red lights. The 12 samples were served in a randomized order according to panelist. The panelists were provided distilled, deionized water and unsalted crackers in order to cleanse their palate after each sample.

Thiobarbituric Acid Reactive Substances (TBARS) Analysis

Using TBARS analysis, lipid oxidation was evaluated using the modified method of Buege and Aust (1978). Steaks were not analyzed by holding time for TBARS. A 10 g sample was placed in a blender (model 51BL31, Waring Products, Inc., Torrington, CT) and homogenized with 30mL of cold deionized water and placed in a disposable tube. Tubes were centrifuged for 10 min and 7°C at 3000rpm. A 2 mL of supernatant was pulled from tube and placed in a glass test tube in duplicates. Each tube had 4 mL of thiobarbituric acid/trichloroacetic acid (TBA/TCA) and 100 µL of butylated hydroxyanisol (BHA). Tubes were vortexed and then incubated in a boiling water bath for 15 min followed by a 10 min cold water bath. Tubes were then centrifuged for 10 min at 25°C at 3000 rpm. The absorbance was read at 531 nm. Standard curves were replicated for analysis using 1,1,3,3-tetra-ethoxypropane (TEP). Amount of lipid oxidation was measured in duplicate for each steak and the average absorbance reading was used for each sample. Results were conveyed as mg of malonaldehyde per kg of sample.

Statistical Analysis

Data were analyzed using the MIXED model of SAS (SAS Inst. Inc., Cary, NC). The model for WBSF, lipid oxidation, and sensory traits included treatment as a fixed effect and sample ID as the random effect to account for the variation. Data were analyzed by holding time for each treatment. In addition, the interaction of holding time x treatment was also analyzed; however, no significant interactions were displayed. The least square means were separated using a protected pairwise t-test when the model displayed a treatment effect ($P < 0.05$).

Results and Discussion

Shear Force

As expected, the CONT was the toughest of the three treatments ($P < 0.05$). Flat iron steaks injected with SUSP technology were more tough than the E steaks, but the difference was not significant ($P = 0.6387$). Several studies have been conducted that show similar results in enhanced product being consistently more tender than a control (Vote et al., 2000; Lawrence et al., 2004; Baublits et al., 2006).

Juiciness

Least squares means for juiciness are presented in Table 1.2. For sustained juiciness at 0 min holding time, the E group showed a tendency to be juicier than the CONT group ($P = 0.0875$). As expected, the SUSP group was significantly juicier than both the CONT ($P < 0.0001$) and E groups ($P = 0.0022$) at time 0. At holding time 30 min, juiciness for the CONT group was not different from the E group ($P = 0.2995$) or the SUSP group ($P = 0.1668$). Juiciness for the E and SUSP treatments were different ($P = 0.0187$), with SUSP being juicier at holding time 30 min. The E treatment was juicier than the CONT, but the difference was not significant ($P = 0.1675$). The SUSP steaks were the juiciest treatment evaluated, outperforming the CONT ($P = 0.0004$) and E groups ($P = 0.0195$) at holding time 60 min. This can be explained by the actual injection percentage of the SUSP steaks being higher than the E steaks. The SUSP steaks retained more total injection than the E steaks, enabling the SUSP treatment to remain juicier during the prolonged post-cooking holding times. Hamling and Calkins (2008) found that increased pump level is positively correlated with an increase in tenderness and juiciness and a decrease in connective tissue. Additionally, Robbins et al. (2003a,b) suggested that enhanced steaks were significantly juicier than non-enhanced beef.

Overall Tenderness

Least squares means for overall tenderness are presented in Table 1.2. For overall tenderness at 0 min holding time, CONT steaks were significantly tougher than the E ($P = 0.0057$) and SUSP ($P < 0.0001$) treatments. This observation was anticipated based solely on the fact that the CONT steaks were left untreated. Steaks from the E group had a tendency to be less tender than those from the SUSP group ($P = 0.0637$) at holding time 0 min. At 30 min holding time, tenderness for the CONT and E group were not different from each other ($P = 0.6339$), whereas the SUSP group was significantly more tender than both the CONT ($P = 0.0011$) and E groups ($P = 0.0049$). The observed results for the 60 min holding time were similar to that of the 30 min holding time for the flat iron steaks. Tenderness of the CONT and E groups were not different ($P = 0.6921$), but the SUSP group was significantly more tender than both the CONT ($P = 0.0023$) and E groups ($P = 0.0056$). Steaks enhanced with SUSP technology were more tender across 30 and 60 min holding times ($P < 0.05$). As seen before, this may have been a result of the differences in total injection percentages between the enhanced treatments.

Connective Tissue

Least squares means for connective tissue content are presented in Table 1.2. At holding time 0 min, there were no differences in connective tissue content for any of the treatments ($P > 0.53$). At holding time 30 min, the CONT flat iron steaks had a higher connective tissue content that the E steaks ($P = 0.05$). There was no difference between the CONT or SUSP flat irons for connective tissue content at the 30 min holding time (P

= 0.2780). The SUSP treatment had lower connective tissue content than the E treatment (*P* = 0.0032) at the 30 min holding time. During the 60 min holding time, there were no differences between any of the treatments for connective tissue content (*P* > 0.1080). Connective tissue content of the treatments varied only for the 30 min holding time. Although the explanation of this is unclear, it may simply be attributed to the panelists detecting the samples to have a small amount of connective tissue that was overlooked and not removed prior to preparation.

Cooked Beef Flavor

Least squares means for cooked beef flavor are presented in Table 1.1. There were no differences (*P* = 0.2065) for cooked beef flavor at 0 min holding time between the CONT and E groups. However, the SUSP treatment had more desirable cooked beef flavor than either the CONT (*P* = 0.0002) or E groups (*P* = 0.0075). For holding time 30 min, the CONT group had a tendency to have less preferred cooked beef flavor than either the E and SUSP treatment groups (*P* = 0.0734). The SUSP and E treatments were not different in terms of cooked beef flavor, yielding the same score at holding time 30 min (*P* = 1.0000). At holding time 60 min, the CONT had less desirable cooked beef flavor than either the E (*P* = 0.0212) or SUSP (*P* = 0.0008) treatments. The E and SUSP treatments were not different in terms of cooked beef flavor (*P* = 0.2278). These findings were in agreement with Vote et al. (2000), demonstrating that injecting beef not only increases tenderness but also enhances cooked beef flavor. Similarly, Stetzer et al. (2008) also found that enhancement with salt and phosphate increased beef flavor. The 50/50 beef trim incorporated in the SUSP enhancement may also have had an impact on the more desirable cooked beef flavor.

Painty/Fishy Off-flavor

Least squares means for painty/fishy off-flavor are presented in Table 1.1. Sensory analysis for painty/fishy off-flavor at holding time 0 min indicated no differences among any of the different treatment groups ($P > 0.05$). At holding time 30 min, no off-flavor was detected for any of the treatments ($P = 1.0000$). Painty/fishy off-flavor for flat iron steaks at the 60 min holding time indicated the most dramatic difference between the CONT and SUSP treatments ($P < 0.0001$), with the SUSP having much lower painty/fishy off-flavor. There was also a difference between the E and SUSP treatments ($P = 0.0236$), indicating that the SUSP treatment was again lower in painty/fishy off-flavor. The E treatment tended to receive lower ratings for detection of painty/fishy off-flavor when compared to the CONT ($P = 0.0566$) at holding time 60 min. These findings demonstrate that the only time painty/fishy off-flavor was detected between any of the treatments was during the 60 min holding time. As a result, serving the steaks inside of the 60 min post-cooking holding time should be ideal for no detection of the painty/fishy off-flavor.

Livery/Metallic Off-flavor

Least squares means for livery/metallic off-flavor are presented in Table 1.1. At holding time 0 min, the CONT steaks had more detectable livery/metallic off-flavor than either the E ($P = 0.0017$) or SUSP ($P < 0.0001$) treatments. However, livery/metallic off-flavor was not different between the enhanced treatments ($P = 0.2063$). At holding time 30 min, the CONT group had more detection of livery/metallic off-flavor than either enhancement treatment ($P < 0.0001$). Livery/metallic off-flavor was not different for the E or SUSP treatments ($P = 0.8662$) at holding time 30 min. At holding time 60 min, no treatment had any detection of the livery/metallic off-flavor (P = 1.0000). These results were surprising for it was expected that the incidence of livery/metallic off-flavor would increase considerably throughout the prolonged holding times. The CONT was expected to have a higher incidence of livery/metallic off-flavor since these steaks received no enhancement, however, the differences of off-flavor detection between the treatments was not as drastic as anticipated. This may be explained by the storage of the steaks inside the plastic bags when they were pulled off the oven and placed into the warmer for the 30 and 60 min holding times. Since the steaks never came into contact with the metal holding trays inside the warmer during their 30 and 60 min holding times, the incidence of livery/metallic off-flavor would not be as drastic compared to if the steaks were placed directly into the trays.

Saltiness

Least squares means for saltiness are presented in Table 1.1. Throughout all holding times, SUSP was rated highest for the detection of saltiness ($P < 0.0007$). This can be explained by the differences in actual injection level of the E and SUSP treatments. The overall injection percentage of the E steaks (3.22%) was well below the targeted 10% while the final injection percentage of the SUSP steaks was 10.77%, indicating that the increase in injection percentage would contain higher levels of sodium. It was found by Robbins et al. (2003a,b) that enhanced beef contains higher salt intensity. Additionally, another study revealed that salt flavor intensity increases significantly when injected into *infraspinatus* steaks (Baublits et al., 2006).

TBARS

All treatments were determined to be different in terms of lipid oxidation ($P < 0.05$) based on the results obtained from TBARS. As expected, steaks from the CONT treatment were shown to be the most oxidized of any treatment with a mean of 0.0595 mg of malonaldehyde per kg of sample. The E treatment was shown to be more oxidized than SUSP ($P < 0.001$) but less oxidized than CONT. The SUSP treatment was the least oxidized ($P < 0.001$) with a mean of 0.0198 mg of malonaldehyde per kg of sample. These observations were to be expected based on the fact that the enhanced treatments contained levels of antioxidants within the formulation. Although the E treatment contained a more elevated level of antioxidant in the brine than the SUSP treatment, less overall brine was retained in E steaks (3.22% compared to 10.77%); therefore SUSP was the superior treatment for least amount of lipid oxidation observed.

Conclusions

These data indicate that both enhancement treatments were superior to the CONT steaks. However, the SUSP treatment was superior in overall tenderness and juiciness and was the most effective treatment for sensory characteristics across holding times with the exception of 3 areas (painty/fishy at 30 min, livery/metallic at 60 min and cooked beef flavor at 30 min), in which the values were the same as at least one other treatment. The SUSP treatment was more effective than the E treatment throughout a majority of the sensory attributes. With the E treatment's actual injection percentage being considerably less than the expected pump percentage; it may not be accurate to conclude that SUSP was superior to E in all of the sensory attributes evaluated. As a result, additional research is needed in order to better compare the enhancement solutions by more closely achieving the targeted injection percentages for each treatment. However, the use of SUSP technology produces added sensory benefits while increasing product consistency and product yield, which in turn will add considerable financial value and increased profitability in the food industry.

Table 1.1. Least squares means for flavor attributes of flat iron steaks (n = 162) stratified by treatment across holding times of 0, 30, and 60 min.

Treatment	Cooked Beef*	Livery/Metallic*	Painty/Fishy*	Salty**
0 min				
CONT	2.40[a]	1.38[a]	1.18	2.14[a]
E[1]	2.51[a]	1.18[b]	1.17	3.08[b]
SUSP[2]	2.75[b]	1.09[b]	1.08	4.68[c]
SEM	0.06	0.04	0.04	0.15
30 min				
CONT	2.43[x]	1.35[a]	1.00	2.32[a]
E[1]	2.55[y]	1.12[b]	1.00	3.55[b]
SUSP[2]	2.55[y]	1.11[b]	1.00	4.69[c]
SEM	0.05	0.04	0.00	0.22
60 min				
CONT	2.42[a]	1.00	1.16[x]	2.28[a]
E[1]	2.54[b]	1.00	1.10[x]	3.75[b]
SUSP[2]	2.61[b]	1.00	1.03[y]	5.37[c]
SEM	0.04	0.00	0.02	0.20

[abc] Means within a subset column without common superscripts differ ($P < 0.05$)
[xy] Means within a subset column without common superscripts had a tendency to differ ($P < 0.10$)
[1] Traditional brine best representing the industry standard resulting in 3.22% injection
[2] Suspension consisting of 50/50 beef trim developed by Cozzini technologies resulting in 10.77% injection
* Evaluated on 3 point scale, 1 = no detection, 2 = slight detection, 3 = strong detection
**Evaluated on 15 point scale, 1 = no detection, 15 = strong detection

Table 1.2. Least squares means for tenderness, juiciness, and connective tissue content of flat iron steaks (n = 162) stratified by treatment across holding times of 0, 30, and 60 min.

Treatment	Tenderness*	Juiciness**	Connective Tissue***
0 min			
CONT	5.99[x]	5.42[a]	6.84
E[1]	6.45[y]	5.75[a]	6.93
SUSP[2]	6.77[y]	6.39[b]	6.93
SEM	0.12	0.14	0.10
30 min			
CONT	6.08[a]	5.82[a]	6.94[a]
E[1]	6.16[a]	5.59[a]	6.65[b]
SUSP[2]	6.65[b]	6.13[b]	7.10[a]
SEM	0.12	0.16	0.10
60 min			
CONT	5.92[a]	4.93[a]	6.87
E[1]	5.98[a]	5.21[a]	6.61
SUSP[2]	6.41[b]	5.67[b]	6.76
SEM	0.11	0.14	0.11

[abc] Means within a subset column without common superscripts differ ($P < 0.05$)
[xy] Means within a subset column without common superscripts had a tendency to differ ($P < 0.10$)
[1] Traditional brine best representing the industry standard resulting in 3.22% injection
[2] Suspension consisting of 50/50 beef trim developed by Cozzini technologies resulting in 10.77% injection
* Evaluated on 8 point scale, 1 = extremely tender, 8 = extremely tough
**Evaluated on 8 point scale, 1 = extremely dry, 8 = extremely juicy
***Evaluated on 8 point scale, 1 = none, 8 = abundant

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VITA

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Master of Science

Thesis: THE INFLUENCE OF POST-COOKING HOLDING TIME ON THE SENSORY ATTRIBUTES OF TRADITIONAL OR SUSPENTEC® ENHANCED FLAT IRON STEAKS

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Abstract

The objective of the study was to evaluate the influence of post-cooking holding time on sensory attributes of flat iron steaks injected with one of two different enhancements or a control. Treatments consisted of a control (CONT), 10% traditional enhancement (E), or a 30% SuspenTec® suspension (patented technology developed by Cozzini technologies, Chicago, IL) technology (SUSP). Flat iron steaks (n = 162) were equally allotted to each treatment, yielding 54 steaks to be used for each. Steaks were enhanced according to their respective treatments, individually vacuum packaged and frozen. Warner-Bratzler shear force, TBARS analysis, and sensory evaluation were determined. Shear force was highest for the CONT and the enhancement treatments were not different from each other ($P < 0.05$). The TBARS analysis displayed SUSP to have the least amount of lipid oxidization of the treatments due to the presence on an antioxidant, whereas CONT contained the highest amount of oxidation ($P < 0.0010$). The SUSP treatment was significantly higher in preferred cooked beef flavor at holding time 0 min and displayed highest numerical scores during the remaining holding times. The SUSP treatment was the preferred treatment for lowest incidence of livery/metallic off-flavor ($P > 0.05$) at holding times 0 and 30 min. No differences were observed for painty/fishy off-flavor at holding times 0 and 30 min for any treatment. At holding time 60 min, SUSP showed a tendency to have the least detection of painty/fishy off-flavor ($P < 0.10$). The SUSP treatment was the saltiest treatment evaluated (P < 0.0007). The SUSP was the most tender across holding times of 30 and 60 min ($P < 0.05$) and also showed a tendency to be most tender at time 0 ($P < 0.10$). The SUSP was also the juiciness treatment across all holding times ($P < 0.05$). In addition to being superior in overall tenderness and juiciness, the SUSP was the most effective treatment analyzed for sensory characteristics across holding times with the exception of 3 areas (painty/fishy at 30 min, livery/metallic at 60 min and cooked beef flavor at 30 min), in which the values were the same as at least one other treatment. Data showed that both enhancement treatments were superior to the CONT in terms of sensory characteristics across all holding times. Additionally, data suggests the tendency for SUSP to outperform E throughout the majority of sensory evaluations in cooked flat iron steaks.

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