ENGINEERED STEAKS AND CHOPS

by
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Engineered Steaks and Chops Not New

The concept of engineered steaks and chops is not new. A book dating from the reign of Augustus (63 B.C. - 14 A.D.) gives recipes for a round sausage of chopped pork, bacon, garlic, onions, and pepper that was stuffed in a casing and smoked until the meat was pink. In recent times a greater percentage of our domestic meat output has gone into some type of structured sausage or processed meat product. At the same time we have seen a greater percentage of the fresh meat consumed as hamburger. A very conservative estimate indicates that the consumption of hamburger, as a percent of total beef consumed, has increased from 36% to 43% since 1972. The retail and the hotel, restaurant and institutional industries are placing increased pressure on meat packers, processors and purveyors to provide them with menu items that are uniform in shape, density, fat content and that have the desired sensory attributes.

The subject of sectioned and formed hams and similar cured meat items has been reviewed recently by Theno (1977) at the Meat Industry Research Conference, and by Schmidt (1978) at the 31st Reciprocal Meats Conference. Addis and Schanus (1979) have recently reviewed the topic of massaging and tumbling of meat. These reviews provide a thorough treatment of the subject of restructuring cured and processed meats.

Massaging and tumbling are physical treatments that result in muscle fiber disruption with a corresponding release of salt soluble protein and coating of the muscles with a soluble protein coat. The protein coat is then heat coagulated by cooking to form a binding matrix between muscle chunks and allows the products to possess the look of "intact" muscle foods such as roasts or hams. It should be pointed out that the presence of salt in the curing brine increases the extractibility of salt soluble proteins to form the matrix which is subsequently stabilized during the smoking and cooking cycle.

The Mind can Only Absorb What the Butt Can Endure

One of the techniques for producing a structured fresh meat item is the use of the Urschel Comitrol with subsequent mixing, pressing to the desired shape and slicing into cuts of the desired thickness. Flaked and formed meats technology was the subject of a presentation by Dr. Mandigo at the 27th Reciprocal Meats Conference (Mandigo 1974). Most of you in the audience today are aware of this technology and the commercial applications by several of the major processors.

Much Research on Engineered Fresh Meats Being Done

Considerable research and development activity in the U.S. and abroad on the technology of engineered fresh meats that more nearly approach the textural and sensory properties of muscle meats have been made. The basic premise in most of these attempts is that, if the cells can be disrupted sufficiently to extract the myofibrillar proteins, a matrix can be developed including the meat pieces and the solubilized proteins. These proteins provide the bonding between the meat pieces. Production of sectioned and formed hams is an ideal situation for this bonding to occur. The presence of salt will raise the ionic concentration sufficiently to extract the myofibrillar proteins. Extraction is enhanced by massaging or tumbling and then the resultant matrix is denatured and thus stabilized during the cooking process.

If we analyze this system it is apparent that two essential ingredients are missing in our attempts at making a sectional and formed steak or chops. First the matrix is not stabilized by cooking in a fresh meat system, and, second, ideally no additives such as salt or phosphate in a fresh meat system would be present.

The challenge is to produce an engineered steak or chop that will bind satisfactorily until cooked and that has the desired sensory properties. Research at Auburn University over the last several years has resulted in a unique approach to the problem. Disrup-

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tion of the cells and extraction of the myofibrillar proteins is accomplished by first mechanically tenderizing the cuts to be used and then to combine chunks of the tenderized meat with either thin slices of meat or meat that has been chopped several revolutions in a silent cutter. A typical processing scheme follows:

1. Boston butts are boned, frozen and tempered to an internal temperature of approximately –2°C and sliced wafer thin, to a thickness of 1-2 mm, on a power cleaver or slicer.

2. Boneless fresh hams are defatted and tenderized one to four times with a reciprocating blade tenderizer at the closest setting, the excess connective tissue and gristle are trimmed off and the meat is cut into 6 to 10 cm cubes. The mechanical tenderizer ensures tenderness of the product as well as better extraction of the myofibrillar porteins for binding. Both chilled and hot-boned hams have been used successfully to produce these tenderized chunks.

3. Various combinations of the wafer sliced butts and tenderized cubed meat are combined in a mixer, and the meat mass is blended for variable periods of time during which time salt, tripolyphosphate or water may be added.

4. The meat is removed from the mixer, preformed into approximately the desired shape, wrapped with PVC film or vacuum extruded into a casing and placed in a sharp freezer.

5. The frozen logs are tempered to an internal temperature of approximately –4°C which requires 24-36 hours in a tempering room.

6. The logs are then pressed into the desired shape at 350-500 psi.

7. The logs are sliced to the desired thickness with a power cleaver using a 20° blade, and the slices are packaged and returned to the freezer.

When beef steaks are desired the same process is followed except that rounds are substituted for hams and chucks, briskets and plates are substituted for boston butts. Obviously the entire carcass may be used as long as the proper pre-formulation is accomplished to assure desired fat content. Variations in bite, mouth feel and other sensory properties can be achieved by altering such processing variables as the ratio of chunks to slice, the proximate analysis, mixing time and the size and shape of the steak or chop.

Research has been reported on the effect of addition of salt and tripolyphosphate (TPP) on physical and sensory properties of pre- and post-rigor pork from market hogs (Huffman and Cordray, 1979).

Experimental Methods:

Post-rigor study: The raw materials used in this study were obtained from 90 kg market hogs slaughtered at the Auburn University Meats Laboratory. Boneless boston butts were removed from carcasses 5 days post-mortem, wrapped with PVC film and frozen at –26°C for 72 hours. After tempering at –4°C for 48 hours, they were sliced to a thickness of 1-2 mm on an automatic slicer.

Hams and sirloin ends were removed from the carcass 5 days post-mortem, boned, then aged an additional 4 days at 2°C. Most of the fat, connective tissue and gristle were removed from the muscle cuts. The cuts were then tenderized 4 times at the 2.54 cm setting on a Bettcher TR-2 tenderizer and cubed into approximately 2 to 3 cm^3 chunks. A total of 22.7 kg of each component of the meat block was prepared.

The four restructured treatment groups were: 1 – restructured pork chops (RPC), no additives; 2 – RPC, salt (.75%) and H_2O (2%) added; 3 – RPC, tripolyphosphate (TPP) (.25%) and H_2O (2%) added; 4 – RPC, salt (.75%), TPP (.25%) and H_2O (2%) added. Each treatment batch was formulated by placing equal portions of slices and chunks with the appropriate additives in a horizontal mixer and mixing for 15 minutes. Ten kg of each treatment was prepared in this manner, subdivided into four equal parts, preformed by hand into logs, wrapped with PVC film and placed in a sharp freezer until the internal temperature reached –26°C. The logs were tempered at –4°C for approximately 48 hours and removed when the internal temperature reached –4°C. The logs were unwrapped and pressed at 344 Newtons/cm^2 on a hydraulic meat press using a 350 die. The formed logs were sliced 2 cm thick using a Model 39 Bettcher power cleaver with a 20° blade. Boneless pork loin chops provided the 5th treatment group and were sliced the same thickness (2 cm) on the power cleaver. All experimental chops were placed 4 to a package in styrofoam trays, PVC overwrapped and placed in a freezer and held 3-4 days at –15°C for subsequent sensory panels and Instron evaluation.

Color evaluation was accomplished by asking 18 trained sensory panel members to rank 2 frozen chops from each treatment group for color desirability on a 1-8 hedonic scale.

Samples were prepared for the sensory panels and Instron evaluation by griddle broiling from the frozen state on a Toastmaster model 350 M griddle. The griddle was preheated 1 hour to a surface temperature of approximately 150°C. Samples were cooked to an internal temperature of 71°C according to the procedures outlined in Meat in the Foodservice Industry

(1975). Cooking losses were calculated on all chops. The chops were evaluated by a trained sensory panel for juiciness, tenderness, flavor, and connective tissue on a 1-8 hedonic scale. Eighteen independent observations were made for each characteristic within each treatment group.

Restructured chops for Instron evaluation were prepared in a manner similar to the sensory panel chops. The chops were cooled 30 minutes at room temperature (23°C), sliced into 1.4 x 5.00 cm strips and placed in the pneumatic jaws of the Instron Model 1122 which were 3 cm apart at the beginning of the test. A crosshead speed of 100 mm/min was used. The Kramer shear compression cell was used on the Instron compression tests. The samples were sliced into 5 cm x 5 cm squares and a crosshead speed of 500 mm/min was used.

Pre-rigor study: The pre-rigor study was done independently of the post-rigor study using the same procedures except that the boneless ham and sirloin chunks were removed from the carcass and manufactured into preformed logs 1½ hours post-mortem. Boneless pork loins were removed from the carcass of the same logs and frozen (−26°C) 1½ hours post-mortem. Loins were tempered to an internal temperature of −4°C, sliced 2 cm thick, packaged in PVC overwrapped styrofoam trays and stored at −15°C for evaluation.

Statistical analyses: Data were treated by analysis of variance. Where significant differences were found, means were separated by Duncan's multiple range test (Steel and Torrie, 1960).

Results and Discussion:

Post-rigor pork: No significant differences (Table 1) were found among the restructured products for tenderness, juiciness, flavor or connective tissue. The boneless pork loin chops were less desirable ($P<.05$) in terms of tenderness, juiciness, flavor, and amount of connective tissue than restructured chops. The restructured chops containing only salt were significantly lower in color score than any of the other chops, while boneless pork chops were significantly higher.

The cooking losses for the treatments containing no additives and the control pork loin chops, were significantly higher than those chops with additives. Chops containing salt and TPP were superior to all the other treatment groups in cooking losses which agrees with results obtained by Neer and Mandigo (1977), Shults and Wierbicki (1973) and Schnell *et al.* (1970).

Instron values for compression were higher ($P<.05$) for the pork loin chops which supports the sensory panel evaluation. Restructured chops with added salt had lower compression values than those without added salt while the addition of TPP had little effect. The Instron evaluation for tension showed the chops with no additives to be significantly lower in cohesiveness when compared to the salt plus TPP chops. The tension evaluation provides the best indication of binding. Salt will solubilize muscle proteins and alter textural properties of emulsion type meats and sectioned and formed hams. It might be expected that the addition of salt provided additional binding in this system.

TABLE 1. Sensory Evaluation, Cooking Loss and Instron Scores for Post-Rigor Pork Chops[abc]

Treatment	Sensory panel evaluation[d]					Cooking Loss	Instron[e]	
	Tenderness	Juiciness	Connective tissue	Flavor	Color	%	Compression	Tension
No additives	6.57a	5.20a	6.03a	6.10a	5.05b	26.9a	217.6b	0.46b
Salt	7.13a	6.17a	6.37a	6.63a	3.45c	19.3b	182.8c	0.53ab
TPP	6.67a	5.63a	6.27a	6.10a	5.55b	19.7b	215.6b	0.53ab
Salt + TPP	6.83a	6.03a	5.87a	6.53a	5.20b	14.6c	187.0c	0.62a
Pork loin chops	2.27b	3.30b	4.23b	4.70b	7.05a	25.1a	358.2a	---
n	3	3	3	3	2	8	5	3
Standard deviation	0.48	0.68	0.62	0.61	0.37	3.15	13.92	0.070

abc - Means in the same column with the same superscript letter are not significantly different ($P<.05$)

[d]1 = extremely undesirable, 8 = extremely desirable
[e] = kg force

This system differs from other processed meats systems where the solubilized protein and meat matrix is immediately heat stabilized, however, it should be noted that this system differs in that the matrix is not heat-stabilized until cooked for consumption.

Pre-rigor pork: No significant differences (Table 2) were found among the restructured pork chop treatments for tenderness, juiciness, connective tissue, and flavor. The boneless pork loin chops were significantly less desirable than restructured chops for the sensory attribute tenderness. The boneless pork loin chops were somewhat lower for juiciness than for restructured pork chops, but were not significantly different from those containing no additives and the salt treatments. Pork loin chops had a higher ($P<.05$) score for connective tissue reflecting the lack of desired tenderness by the panelists. It is apparent that the addition of TPP, alone or in combination with salt, affects juiciness. The color evaluation of the pork loin chops rated significantly higher than all the restructured products except for the salt plus TPP treatment.

Cooking loss was significantly higher for control restructured chops than all other treatment groups. Addition of TPP alone lowered the cooking loss ($P<.05$) and the addition of salt alone resulted in a decrease ($P<.05$) over TPP alone, but not significantly different from the pork loin chops. When salt and TPP were combined the cooking loss of 14.8% was significantly lower than all restructured treatments and pork loin chops. Apparently a slight synergistic effect of adding the combination of TPP and salt results. These findings are in agreement with Neer and Mandigo (1977), Shults and Wierbicki (1973) and Schnell *et al.* (1970).

Instron compression scores for pork loin chops confirmed sensory panel evaluation that pork loin chops were less tender than restructured products. Control restructured chops had lower ($P<.05$) compression ratings than chops containing salt or salt plus TPP, but were not different from chops containing TPP only.

Tension scores for restructured chops provide evidence of improved binding with the addition of salt over control chops or chops containing TPP. This finding confirms results of the post-rigor study regarding salting-out of protein during the mixing phase that are later stabilized during cooking.

Conclusions:

Restructured pork products, using the process described, have a more desirable eating quality than pork loin chops whether processed from pre-rigor or post-rigor pork. Color of restructured products is less desirable than pork loin chops with the addition of salt further lowering color desirability. Cooking loss is decreased by the addition of salt and TPP in combination.

In a study designed to determine the effect of salt concentration on quality of sectioned and formed pork chops (Ly *et al.* 1979) sow raw materials were used rather than raw materials from market hogs. The manufacturing process was identical to that outlined previously except that fat content was adjusted to approximately 15% during the mixing cycle by the addition of fine ground back fat. Four treatment groups (Table 3) were 0, 0.5%, 1.0%, and 1.5% added salt. Chops were evaluated at 0 and 30 days of freezer storage for rancidity (TBA), sensory properties

TABLE 2. Sensory Evaluation, Cooking Loss and Instron Scores for Pre-Rigor Pork Chops[abcd]

Treatment	Sensory panel evaluation[e]					Cooking Loss	Instron[f]	
	Tenderness	Juiciness	Connective tissue	Flavor	Color	%	Compression	Tension
No additives	6.47a	5.47ab	5.87a	5.97a	4.45b	27.9a	297.2b	0.23c
Salt	6.50a	5.87ab	5.63a	6.03a	4.40b	20.1c	246.6c	0.34ab
TPP	5.87a	5.60a	5.63a	6.07a	4.65b	23.9b	270.8bc	0.29bc
Salt + TPP	6.40a	6.20a	5.43a	6.23a	5.00ab	14.8d	228.8c	0.43a
Pork loin chops	4.20b	4.43b	6.77b	5.37a	6.55a	18.6c	349.6a	---
n	3	3	3	3	2	8	5	3
Standard deviation	0.75	0.72	0.36	0.62	0.61	2.58	31.92	0.046

abcd - Means in the same column with the same superscript letter are not significantly different ($P<.05$)

[e] 1 = extremely undesirable, 8 = extremely desirable
[f] = kg force

and Instron tension and compression. The experiment was replicated three times and analyzed statistically as previously described.

Results and Discussion:

The results of the triangle tests indicated that significant differences between all treatments except the 1.0% and 1.5% salt treatments that had been stored for 30 days were found. The reason that the panelists were unable to detect a difference in these two treatment groups at 30 days storage is that they were both rancid. This observation is confirmed by the results of the TBA tests.

Results of the sensory evaluation, TBA tests and Instron evaluation are shown in Table 3. A linear response of salt level to rancidity was found as shown by the significant increase in TBA number with each incremental increase in salt content following 30 days freezer storage. Flavor of the chops that were stored for 30 days was less desirable than comparable chops evaluated prior to storage. The addition of salt significantly improved flavor ratings of chops up to the 1.0% level.

Color of chops prior to storage was not significantly effected by salt concentration until the level reached 1.5%. However, salt concentration had a significant effect on color at every increment following freezer storage. Juiciness and textural properties were effected in a similar manner by the addition of salt. Instron compression scores reflect textural properties decreased in a linear fashion with each increment of salt. Based on these three sets of observations a salt level between 0.5% and 1.0% would seem to be most desirable. Cooking loss was significantly decreased by the addition of as little as 0.5% salt. Cooking loss figures shown in this table are higher than would normally be expected for restructured pork chops. This is likely due to the fact that sow raw materials were used and that the water holding capacity of this tissue is less than for market hog raw materials.

One of the major criteria for success in this type experiment is the ability of the system to bond pieces of meat together. The best measure of this bonding is the Instron tension test. A significant linear response to the addition of salt indicated that the addition of salt does, indeed, result in superior extraction of myofibrillar proteins and hence superior bonding of the meat pieces.

TABLE 3. Sensory evaluation, cooking loss, TBA and Instron scores for sectioned and formed pork chops

	Time of storage[1] (days)	Treatment (% salt) 0.0	0.5	1.0	1.5
TBA[2]	0	0.18[a]	0.49[a]	0.70[a]	1.03[a]
	30	0.26[a]	1.89[b]	4.55[c]	6.38[d]
Juiciness[3]	0	4.3[a]	5.2[b]	6.0[c]	6.1[c]
	30	4.5[a]	5.1[b]	5.7[b]	5.5[b]
Textural properties[3]	0	4.4[a]	5.3[b]	6.0[c]	6.2[c]
	30	4.8[a]	5.2[a]	5.8[b]	5.8[b]
Flavor[3]	0	4.6[a]	5.6[b]	6.6[c]	6.2[c]
	30	4.9[a]	5.0[a]	5.0[a]	5.2[a]
Color[3]	0	5.2[a]	5.5[a]	5.0[a]	3.5[b]
	30	6.3[a]	5.2[b]	2.6[c]	1.9[d]
Cooking loss (%)	0	40.8[a]	33.4[b]	32.6[b]	30.4[b]
	30	38.1[a]	33.9[b]	31.2[b]	29.5[b]
Instron compression[4]	0	560[c]	479[b]	549[c]	421[a]
Instron tension[4]	0	199[a]	254[b]	316[c]	345[d]

[1]Stored at -34°C.
[2]Mg malonaldehyde/kg sample.
[3]Scale 1 = extremely undesirable; 8 = extremely desirable.
[4]Kg force.
[a,b,c,d]Means on the same line with the same superscript letter are not significantly different (P<.05).

Conclusion:

The level of salt is critical in production of restructured pork chops. Bonding of muscle pieces is improved, cooking loss is improved as are flavor, juiciness, and textural properties. Rancidity and the attendant problems of off flavor and color are a problem following freezer storage.

Considerable research effort with beef is currently underway at Auburn. This research effort is related to an ongoing project on forage-fed beef from exotic and dairy crosses as well as from young bulls. A brief illustration of the type of research underway is given here.

The carcasses of two 14-month old Charolais x Angus bulls were chilled 48 hours at 2°C, the chucks and rounds were removed, boned, and defatted. The boneless chucks were frozen overnight at –30°C, tempered for 36 hours at –3°C, and sliced wafer thin on an automatic slicer. The boneless rounds were tenderized three times using a reciprocating blade tenderizer with a belt setting of 2.54 cm per advance. This tenderization assured maximum cell disruption. The rounds were then cut into 6 to 10 cm cubes and the excess gristle and connective tissue were trimmed off.

Steps in forming the steaks were as follows: (1) 10 kg each of the wafer sliced chunks and tenderized beef cubes were blended in a Hobart horizontal mixer for 15 minutes and formed into logs; (2) the logs were frozen at –30°C for 48 hours and tempered at –3°C for 36 hours; (3) the logs were pressed using a 7.6 cm diameter cylindrical die in a hydraulic press, and then sliced into 2 cm-thick steaks.

Steaks for the salt added treatment were prepared in exactly the same way except that 0.75% salt and 454 gms of water were added to the meat at the beginning of the mixing cycle. All steaks were placed in styrofoam trays, PVC overwrapped, and frozen for subsequent sensory and Instron evaluation.

Color was evaluated on two steaks from each treatment by a 6-member trained sensory panel. Steaks were prepared for the panels and for Instron evaluation by griddle broiling to an internal temperature of 70°C on a commercial electric griddle. Cooking loss was determined by weighing steaks before and after cooking.

The sensory properties, tenderness, juiciness, flavor, and amount of connective tissue, were evaluated by the panel using an 8-point rating scale. Instron tension scores reflect the force required to pull a 1.4 x 5-cm strip of cooked steak into two pieces.

As shown in Table 4, the sensory panel noticed no significant difference in tenderness nor amount of connective tissue between steaks containing salt and the control steaks. The average values for juiciness were slightly higher for the steaks containing salt than the control steaks, and cooking loss was significantly lower for salt treated steaks. Adding salt caused improvement in flavor, according to the sensory panel. Panelists were permitted to use salt on the cooked sample during testing if desired, so the flavor difference noted was related to flavor alteration of the meat mix during processing and cooking.

Previous research also found that flavor was enhanced by incorporation of salt into the meat mix. The same research also showed that steaks containing salt develop off-flavors during freezer storage. Color of steaks containing salt was significantly more desirable than the color of control steaks. This agrees with results of previous studies with restructured beef steaks.

TABLE 4. Sensory evaluation, cooking loss and Instron evaluation of restructured steaks

Item	Control	Salt added
Sensory panel[1]		
Tenderness	5.3	5.5
Juiciness	4.4	5.0
Connective tissue	5.4	5.9
Flavor	5.2	6.2
Color	4.0	4.7*
Instron values		
Compression (kg)	838	755*
Tension (kg)	.024	.057*
Cooking loss, pct.	33.4	31.8*

[1] 1 = extremely undesirable and 8 = extremely desirable.
*P<.05

Physical properties of the cooked restructured steaks containing salt were superior to the controls as evaluated by the Instron. Compression scores were significantly lower and the tension scores were significantly higher for the salt treatment. This indicates that the meat particles bound together better with salt addition, but still retained more desirable compression scores, which is indicative of desired tenderness.

The reported findings established that a highly desirable restructured steak product can be manufactured from young bull beef. Based on this study, the addition of 0.75% salt provides improved sensory and physical properties.

Present research on beef involves the use of a high speed silent cutter to reduce the particle size of the fatter component of the mix. Efforts also are continuing on the use of a vacuum stuffer for extrusion of logs.

Future research needs are considerable. Attention should be focused on more rapid methods of freeze-tempering. Research completed in a cooperative effort with Auburn University, Texas A&M University, Standard Meat Co., and Bettcher Industries (Calkins *et al.* 1979 and Savell *et al.* (1979) should serve as a background to further efforts on crust freezing of restructured meats. Innovations in equipment should be researched at the University level. An example of such equipment is the co-extrusion system and the desinewing equipment manufactured by the Beehive Corporation.

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