THIAMIN CONTENT AND SENSORY EVALUATION OF POST-MORTEM PAPAIN-INJECTED CHICKEN COOKED IN MICROWAVE AND CONVENTIONAL OVENS

by

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TABLE OF CONTENTS

INTRODUCTION

Baking hens make up a large portion of ready-to-cook poultry and could be better utilized if a method of efficient and economical tenderization could be perfected. Enzymatic tenderization using proteolytic enzymes derived from plant or mold sources is one method that may be used to tenderize poultry meat. The USDA has recently approved the use of enzymes including papain, bromelin and ficin, from plant sources, and Aspergillus oryzae and Aspergillus flavus oryzae groups, derived from mold sources, for tenderizing mature poultry meat. Those enzymes also are permitted in beef, pork, lamb, mutton, and goat. Objectives of this project were: (1) to assess effects of injection of a proteolytic enzyme, papain, on the thiamin content of baking hens cooked conventionally and by a microwave oven, and (2) to determine sensory characteristics and Instron measurements of baking hens injected with papain at three levels of concentration.

REVIEW OF LITERATURE

The following review of literature contains information on proteolytic enzyme action on myofibrils, connective tissue, and free amino acid liberation. Methods of application of enzymes to meat systems are discussed and include surface treatment by powder, immersion and injection. Information on nutrient retention in poultry and microwave cooking of meat is also given.

Enzyme Action

Meat treated with enzyme preparations is tenderized in a different way than is age-tenderized meat. Birkner and Auerbach (1960) reported that histological changes during aging include disappearance of cross striations and the onset of transverse breaks. Kinks or waves seen in the fibers disappear and collagen decreases, but elastin is not affected. On the contrary, enzyme preparations act on the muscle fiber, breaking down the sarcolemma and the nuclei; this is followed by disintegration of endomysial collagen, connective tissue collagen and elastin; and finally there is complete disappearance of cross striations (Landmann, 1963).

Specific action of proteolytic enzymes on various meat systems has been studied. Kang and Rice (1970) studied the effect of various enzymes on meat protein fractions. Bromelin and trypsin degraded the connective tissue fraction of the muscle tissue to a greater degree than the fiber portion. However papain and ficin degraded the myofibrillar fraction more than the connective tissue. Wells et al, (1965), using papain at a concentration of .002% on freeze-dried chicken, also found only minor breakdown of connective tissue, but extensive degradation of the muscle fibers to the extent of complete destruction of the sarcolemma, loss of striations and disappearance of the nuclei. Wismer-Pedersen (1972) using various enzyme preparations found bromelin, collagenase, and trypsin extremely effective for tenderizing the connective tissue, collagen. Preparations of papain and ficin were distributed poorly in the meat samples and results were not given. Wang et al, (1957), using rehydrated slices of freeze-dried steaks, immersed the steaks in a papain solution for 30 seconds at 40^{o}F. The enzyme was active on the muscle fiber. Dissolution of the sarcolemma was the earliest change, followed by disappearance of the cross striations. The collagenous tissue was only slightly altered by the papain, but the enzyme showed moderate activity in digesting the elastin.

Degradation of Myofibrils. Robbins et al, (1979) used SDS (sodium dodecyl sulphate) gel electrophoresis to show the effects of papain on bovine myofibrils. Myofibrillar proteins, myosin, actinin, and actin, were degraded and formed peptides with lower molecular weights. Rattrie and Regenstein (1977) subjected actin and myosin heavy chains isolated from chicken breast muscle to crude papain at a level of 1:125 w/w. SDS electrophoresis of the myofibrillar proteins indicated that papain digested actin rapidly and produced major degradation products. The myosin was degraded slower and only 40% of the heavy chain was cleaved after 3 min. Actomyosin was less rapidly digested than the myosin.

Degradation of Connective Tissue. Miyada and Tappel (1956) used papain at a 0.05% level to digest rehydrated, ground, freeze-dried biceps femoris muscle of beef. The insoluble protein fraction was separated into collagen and elastin. Papain did not digest collagen, but the elastin protein was digested to some extent. The resistance of collagen to papain was studied by Neuman and Tytell (1950), who extracted collagens from several sources including chicken tendon, sheep tendon, and cattle-tail tendon. The collagens were prepared so as not to alter their natural properties. Those collagens were shownto be resistant to the action of papain and also resistant to trypsin and chymotrypsin.

Free Amino Acid Formation. The formation of free amino acids in meats is one way to measure the extent of protein degradation. Youn et al, (1973a) determined the amino acid content of fore-shank muscles and then immersed the samples in 0.01, 0.05, and 0.1% papain solutions. All enzyme concentrations increased the levels of leucine, lysine, and arginine. Proline and histidine were decreased by addition of 0.01% enzyme but increased with the higher enzyme concentrations. Aspartic acid, threonine, serine, methionine, tyrosine, and phenylalanine increased with 0.01 and 0.05% enzyme, but decreased in level with 0.1% enzyme. Youn et al, (1973b) studied total and free tryptophan contents in the fore-shank muscles of beef. Addition of 0.01, 0.05, and 0.1% papain steadily increased the content of free tryptophan.

Methods of Application

Papain has been applied to meats for tenderization purposes in a number of ways. Powder application to the meat surface, immersing the meat in the enzyme solution, and injection have all been used.

Powder Application. Tappel et al, (1956) applied a thick layer of papain to the surface of USDA choice semitendinosus muscle cut 5/8 in. thick, and parallel to the length of the muscle fiber. After 3 hr. of exposure at room temperature, no histological changes were evident with all muscle fibers intact and few noticable disturbances in striation patterns. After broiling for 10 min, the sarcolemma was destroyed at the surface and marked separation of muscle fibers was evident. Deeper in the meat, the sarcolemma was undisturbed. Papain was shown to have maximum hydrolysis of elastin at 60^{o}C. Hay et al, (1953), using round steak, sirloin tip steak, and rump roasts, applied papain by sprinkling the enzyme on the meat surface with a salt shaker and then piercing the surface with a fork to provide deeper penetration before cooking. No significant difference in cooking losses, aroma, and flavor of treated and untreated samples were found. For top round steak, bottom round steak and sirloin tip steak, all treated samples significantly increased in tenderness (by panel evaluation) and shear values decreased.

Immersion. Application of papain by immersion can include immersing a sample in enzyme solution or rehydrating freeze-dried samples of papain solution. Wang et al, (1957) rehydrated freeze-dried steaks in an aqueous solution of papain. Steaks were cooked to $150^{\circ}F$ and panel members were asked to pick the different sample by triangle testing, and rate its tenderness on a 1-10 scale. The selection of the odd sample by panel members showed flavor difference in the papain sample and also increased tenderness. Youn and Yang (1974) treated beef with papain (0.01, 0.05, and 0.1% solution) by soaking for 40-60 min at $25^{\circ}C$ and $10^{\circ}C$. Sensory evalution indicated preference for samples at 0.05% solution at $25^{\circ}C$ and a lesser preference for those soaked at $10^{\circ}C$. Youn and Yang (1975) also treated round steaks with 0.01, 0.05, and 0.1% papain solutions and measured tenderness using a penetrometer. Penetration values increased proportionally with increasing papain concentrations. At the 0.05% papain level, there was significant increase in tenderness, but no further significant increase in tenderness with a 0.1% solution. Dawson and Wells (1969), using a five-member panel, reported 0.002% as being the optimum papain concentration for tenderization and acceptability of freeze-dried chicken. At levels up to 0.05% the meat was extremely tender but not acceptable to the panel.

Injection. Introduction of papain solution into a meat system by injection has been studied. Rogers et al, (1965) injected dry cured country-style hams with 5 ppm papain solution. Taste panel members scored non-treated control hams significantly higher for flavor, saltiness and overall acceptability. Treated hams were significantly higher for tenderness but were generally too mushy to be acceptable. Haleem et al, (1970) reported post-slaughter intramuscular injection at concentrations of 100 mg and 300 mg per bird resulted in "mushy" muscle tissue. Sensory evaluation of the light and dark meat by five panel members indicated an increase in tenderness and juiciness as the enzyme concentration increased, but a decrease in flavor acceptance. Sosbee et al, (1964) found papain was effective in increasing tenderness in freeze-dried chicken. It increased tenderness to the point of being mushy when treated with a concentration of 0.003% papain. The meat was not tenderized uniformly with the collagen showing extensive degradation and the fibers showing little change. Fry et al, (1966) injected papain solution (4 oz in 3.5 gal water) into turkey rolls at levels of 3 and 6% based on weight of turkey roll. The enzyme tended to migrate to the bottom of the roll during cooking, resulting in a tough muscle portion at the top of the roll and an overtenderized, mushy product on the bottom of the roll. No sensory data was available because of the undesirability of the post-mortem injected product.

Several studies have investigated different ways of enzyme addition to the same meat system. Wang and Nehema (1955) subjected oneset of raw beef semitendonosis muscles to papain powder for 5, 10, and 15 min and another set to immersion in 10% solution for 5, 15, 30, and 60 min. Although the liquid enzyme preparation penetrated into the meat more than the powdered preparation, both methods proved impractical because of limited penetration (less than 1 mm in one hour by the powder). Kann et al, (1974) used papain as a surface powder, soak solution and injection solution in treating beef neck and shoulder muscles. Four treatments were used: (1) sprinkling papain together with salt on both sides and holding for 10 min, (2) immersing pieces previously beaten with a meat hammer in enzyme and salt solutions and holding for 10 min, (3) as 2 with mechanical stirring, and (4) injecting 2-4 kg pieces and holding for 10 min. Panel members evaluated fried samples and found methods 3 and 4 to be the most satisfactory for producing an acceptable product.

Nutrient Retention

When a tenderizing enzyme is introduced into a meat system, another step is added to the processing procedure. This additional processing procedure may affect nutrient retention or nutrient level of the muscle system.

Minerals. Retention of minerals in poultry has been studied only on a limited basis. Generally, normal cooking and processing do not affect, appreciably, the quantity or availability of minerals in meat. Though small amounts do leach into the cooking liquid or juices, it is difficult to evaluate that loss from the nutritional standpoint because the drippings from meat may sometimes be used in gravies or in soup preparation. Zenoble and Bowers (1977) studied the zinc, iron, and copper contents of turkey and found all cooked meat values (expressed on an edible weight basis) were higher than raw meat values, except in breast muscle where the copper contents of raw and cooked samples were similar. When values were expressed on a moisture and fat-free basis, generally the mineral content of cooked muscle was less than that of raw muscle.

Changes in mineral concentrations in tissues have been studied when papain is injected ante-mortem into an animal. Marten et al, (1975) intravenously injected roosters and laying hens with a papain solution (4 mg papain/ml at 2.5 ml papain solution per kg of body wt) to determine the effect on the concentration of calcium, iron, copper, zinc, and selenium. Results indicated papain had no significant effect on the concentrations of any of the elements in the tissues.

Vitamins. No information is available on vitamin retention in meat systems after the addition of an enzyme for tenderization. Losses of vitamins during preparation and cooking are caused by leaching from the muscle and/or by heat destruction. Thiamin, a water soluble vitamin present in muscle tissue is one of the least stable vitamins. Robinson and Lawler (1977) reported thiamin losses up to 25% when meats are broiled or roasted. They also reported that when meats are cooked in liquid, thiamin losses approach 50% if the liquid is discarded. Mickelsen et al, (1939), studying meat and meat products found only slight destruction of thiamin during frying but in roasting, broiling or stewing, the vitamin destruction may reach 50%.

Thiamin retention and distribution in poultry meat has been the object of numerous studies. Morgan et al, (1949) concluded that 20-40%

of the thiamin present was destroyed when broiler hens were cooked by broiling and amounts were not affected by frozen storage. Dark meat muscle contained 2-3 times more thiamin than light meat muscle and amounts were not affected by frozen storage. Millores and Follers (1949) also reported that dark meat contained more thiamin than light meat muscle and that curing, smoking and canning chicken may result in up to 80% loss of the original content of thiamin. Lachance et al, (1973) reported a 18% loss of thiamin upon heating of chicken pot pie filling.

Microwave Cooking of Meat

If older poultry muscle could be tenderized enzymatically, the resulting product might be suitable for microwave cooking or other rapid methods of cooking. Several studies on microwave cookery of meat have been reported. Korschgen et al, (1976) reported significantly greater cooking losses for microwave cooking than for conventional roasting of the longissimus dorsi muscle of beef and pork. Deethardt et al, (1973) reported significantly more drip loss in microwave cooked roasts when compared with oven roasted samples. Ground beef patties cooked by microwaves were found by Janicki and Appledorf (1974) to be lower in moisture and crude fat than patties cooked by broiling or grill frying. Ream et al, (1974) found beef arm roasts cooked in a microwave oven to be less tender, juicy, and flavorful than similar cuts cooked in a conventional oven. Top round of beef could not be satisfactorily cooked in a microwave oven. Portions of the roast became very hard and dry and were unpalatable (Marshall, 1960). Larger, less tender cuts of meat usually cannot be satisfactory cooked in a microwave oven.

Thiamin losses in meats cooked by microwaves have been studied. Kylen et al, (1964) reported losses of thiamin in beef roasts cooked in a microwave oven to range from 33 to 42%. Roasts cooked conventionally retained slightly higher amounts. Thomas et al, (1949) cooked beef patties by microwaves and compared them to conventionally grilled patties. The samples cooked in the microwave oven had higher thiamin values than the conventionally cooked samples. Bowers and Fryer (1972) reported that the type of oven, conventional or microwave, did not have any significant effect on the thiamin retention in turkey muscle. Little information is available on the effects of microwave cooking and thiamin retention in chicken muscle.

MATERIALS AND METHODS

Treatments

Six treatment combinations for post-mortem injection and cooking of hens were studied - three levels of papain (0.000, 0.001, and 0.002%) and two cooking methods (conventional and microwave). A randomized complete block design with five replications of each treatment was used (Table 4, Appendix). A block was two evaluation periods (with 3 treatments evaluated each period) within the same week.

Papain Injection. Forty frozen baking hens weighing from 1654 to 2985 g were obtained commercially and allowed to thaw overnight at room temperature before injection. The designated solution (0.000, 0.001, and 0.002% papain[1] in distilled water) was injected at 4% of hen weight in 50 sites distributed in the breast, thigh, and leg muscles according to a template designed for even distribution. Ten hens were not injected and served as controls for thiamin determination. Hens were packaged in plastic bags and over-wrapped in foil, frozen, and held 2 to 7 weeks at -18°C until evaluated.

Cooking. Prior to each of ten cooking periods, hens were thawed eight hours at room temperature and then refrigerated approximately 39 hrs. After thawing, the hens were wrapped in oven proof film, placed in baking dishes and thermometers were inserted in the thigh and breast muscles. Conventionally cooked hens were cooked breast-down in a rotary hearth oven at 350°F for 30 min, turned breast-up and cooked until an endpoint temperature of 85°C was reached. Microwave (Amana Model RR 7DA, on roast cycle) cooked hens were heated breast-down for ten min, turned over and cooked with the breast-up to the 85°C endpoint temperature. All birds were weighed before and after cooking to determine cooking losses.

Evaluation and Measurements

[1]Papain (Takamine Brand Papain 30,000, F.C.C., E.C. 3.4.4.10 a peptidohydrolase) was obtained from the Enzyme Products Division, Miles Laboratories, Inc., Elkhart, IN.

Sensory Evaluation. The upper portion of the pectoralis major (breast) muscle was used for sensory evaluation. Samples (4 X 1½ X ½ cm) were cut perpendicular to the muscle fibers. A seven-point intensity scale (Form 1, Appendix) was used by the eleven-member trained taste panel for evaluation of tenderness, chicken flavor, off-flavor, juiciness, and mealiness.

Instron Measurements. The lower portion of the pectoralis major (breast) muscle was used for textural measurement by the Instron Universal Testing Machine, Model 1122. Duplicate samples (4 X 1 X ½ cm) for measurement of connective tissue strength between fibers were cut perpendicular to the muscle fibers. Other samples (4 X ½ X ½ cm) for measurement of fiber strength, were cut parallel to the muscle fibers. Samples were placed between tensile grips 2 cm apart. The grips were mounted on the Instron and pulled apart with 0.2 kg of force applied by a crosshead speed of 20 mm per min and the curve (Fig 1, Appendix) was graphed at chart speed of 100 mm per min. Three measurements were taken from the curves: (1) length of the peak height; (2) distance from the beginning of the curve to the peak height; and (3) the width of the curve at ½ peak height.

Thiamin, Moisture, and Fat Determination. Thiamin, moisture, and fat contents of a composite of thigh muscles were determined. Both thighs were skinned, deboned, and ground twice through a 0.5 cm plate. Percentages of fat and moisture were determined by AOAC procedure (1975). Thiamin was determined by the thiochrome method (Freed 1966). Samples were prepared by extracting 20 grams ground thigh tissue with 0.1 N HCl in a Brinkman homogenizer. The Decalso purification was not necessary and was omitted from the procedure. Fluorescence of the thiochrome was determined by a Coleman, Model 12C, photofluorometer.

Analysis of Data

Taste Panel. Taste panel scores were subjected to analysis of variance using the following design:

Source	Degrees of Freedom
Block	4
Method	1
Level	2
Member	10
Method X Level	2
Method X Member	10
Level X Member	20
Total	49

Thiamin and Instron. Thiamin and Instron data were subjected to analysis of variance using the designs shown:

Source	Degrees of Freedom	
	Thiamin	Instron
Block	4	4
Method	1	1
Level	3	2
Method X Level	3	2
	Total 11	Total 9

Fat, Moisture, and Cooking Losses. Fat, moisture and cooking loss values were subjected to analysis of variance using the designs shown:

Source	Degrees of Freedom
Method	1
Level	3
Method X Level	3
Total	7

When F-values were significant, least significant differences (LSD) at the 5% level were calculated.

RESULTS AND DISCUSSION

Taste panel scores, Instron measurements, and thiamin, fat, and moisture contents of papain injected baking hens cooked by two methods were evaluated. Data for all replications are presented in Tables 5-11, Appendix.

Sensory Evaluation

Results of the eleven-membered taste panel evaluation for tenderness, roast chicken flavor, off-flavor, mealiness, and juiciness using a seven-point intensity scale are presented (Table 1).

Tenderness and Mealiness. Samples were more tender ($P<0.001$) when papain was introduced into the meat system. Similar results were found in meat by Hay et al, (1953) in steaks, Rodgers et al, (1965) with hams, and Sosebee et al, (1964) in freeze-dried chicken. The microwave cooked bird increased in tenderness when the papain concentration was doubled (0.002%). Haleem et al, (1970) reported similar increases in tenderness in poultry with papain concentrations of 100 and 300 mg per bird. The conventionally cooked hens increased in tenderness ($P<0.01$) when papain was injected (0.001%), but did not increase in tenderness when the higher concentration (0.002%) of papain was added. Youn et al, (1975) reported the same trend in tenderness using round steaks with 0.05 and 0.1% papain concentrations.

Mealiness of samples tended to increase with addition of papain. However, no significant difference was noted between samples cooked in the microwave oven. For those conventionally cooked, mealiness increased ($P<0.01$) with 0.001% and 0.002% papain concentrations.

Table 1 - Intensity scores[1,2] for tenderness, juiciness, mealiness, roast chicken flavor, and off-flavor of baking hens.

	Tenderness	Mealiness	Roast Chicken Flavor	Off-Flavor	Juiciness
Treatments[3]					
Microwave					
.000% papain	3.9[b]	3.8[ab]	3.8[b]	3.0[ab]	3.7[ab]
.001% papain	4.5[c]	3.8[ab]	3.5[a]	3.3[bc]	3.4[a]
.002% papain	5.1[d]	4.0[bc]	3.3[a]	3.6[c]	3.8[b]
Conventional					
.000% papain	3.3[a]	3.4[a]	3.8[b]	2.7[a]	3.5[ab]
.001% papain	5.1[d]	4.3[bc]	3.4[a]	3.3[bc]	3.7[ab]
.002% papain	4.7[cd]	4.5[c]	3.5[a]	3.6[c]	3.4[a]
Significance of F-Value[4]					
Method	ns	ns	ns	ns	ns
Level	***	*	*	***	ns
Meth X Level	**	**	ns	ns	**
LSD[5]	.52	.54	.30	.43	.39

[1]1, extremely tough, no chicken flavor, no off-flavor, extremely dry, or not mealy to 7, extremely tender, extremely intense chicken flavor, extremely intense off-flavor, extremely juicy, or extremely mealy
[2]Mean of 5 replications
[3]See Table 4, Appendix
[4]***, significance at 0.1% level
**, significance at 1% level
*, significance at 5% level
ns, not significant
[5]Least significant difference at 5% level

Although significant differences in tenderness scores between microwave and conventionally cooked hens were found, trends were not consistent for the 3 papain levels. With no papain, microwave cooked hens were more tender than those conventionally cooked, but with 0.001% papain, microwave cooked hens were less tender.

Flavor and Off-flavor. The roast chicken flavor decreased ($P<0.05$) and the off-flavor increased ($P<0.001$) when papain was added to the meat system (0.001 and 0.002%). The off-flavor could be attributed to the papain present or to additional free amino acids liberated in the cooked muscle. Ishida and Yamamoto (1976) reported hydrolysates from chicken meat treated with an endopeptidase, papain, were found to have a bitter taste. Flavor differences between papain treated and nontreated samples were also detected by Wang et al, (1957) with freeze-dried rehydrated steaks and by Haleem et al, (1970) who evaluated light and dark poultry meat and indicated a decrease in flavor acceptance. Although an off-flavor was detected, the panel members in our study ranked the intensity only as slight. At this low level of intensity, off-flavors may not be a drawback to this method of tenderization.

Juiciness. Slight differences in juiciness among papain-injected hens were observed, although trends were not consistent for either microwave or conventionally cooked hens. For microwave cooked hens, those injected with 0.001% papain were less juicy than those injected with 0.002%. Haleem et al, (1970) also detected juiciness results such as these in papain injected poultry. For conventionally cooked hens, differences were not significant.

Objective Measurements

Instron. Measurements calculated from Instron curves are reported (Table 2). Measurements of fiber strength from Instron curves were not different. However, others (Kang and Rice (1970), Wells et al, (1965), and Robbins et al, (1979)) have reported papain as being effective in degrading the fiber portion of muscle tissue.

The strength of the connective tissue between fibers was reduced ($P<0.05$) in conventionally cooked birds when papain was injected. When length to the peak height (extensibility before breaking) was measured, a difference ($P<0.05$) was noted between levels of papain injection. This distance decreased significantly when papain was added to the muscle (.001 and .002%).

Cooking Loss, Moisture, Ether Extract, and Thiamin. Cooking losses, moisture, fat, and thiamin contents of hens are presented in Table 3. No significant difference was noted in total cooking loss between cooking methods. Contrary results were reported by Korschgen et al (1976), who found greater cooking losses from microwave ovens using longissimus dorsi muscles from beef, pork and lamb. Level of papain injection did not affect cooking loss. Even in hens receiving no injection (control birds for thiamin), no difference existed between those and injected hens. Thaw losses tended to be greater for injected birds than for untreated, but differences were not significant.

Percentages of ether extract and moisture of the cooked thigh muscle were not significantly different between cooking methods (microwave and conventional) or among papain-injected hens.

Table 2-Measurements[1] from Instron curves (cm) for muscle fiber and connective tissue.

	FIBER			CONNECTIVE TISSUE		
	Peak Height	Distance to Peak Height	Width at ½ Peak Height	Peak Height	Distance to Peak Height	Width at ½ Peak Height
Treatments[2]						
Microwave						
.000% papain	6.6	2.3	4.1	6.9	4.0[b]	4.8
.001% papain	6.3	2.2	2.8	6.0	3.2[a]	4.1
.002% papain	5.8	2.2	3.0	7.1	3.4[a]	6.5
Conventional						
.000% papain	4.8	3.5	5.4	6.6	4.6[bc]	5.7
.001% papain	5.1	2.2	3.0	4.2	3.7[b]	4.3
.002% papain	4.9	2.9	3.7	5.0	3.1[a]	4.6
Significance of F-Value[3]						
Method	ns	ns	ns	*	ns	ns
Level	ns	ns	ns	ns	*	ns
Meth X Level	ns	ns	ns	ns	ns	ns
LSD[4]	-	-	-	-	.39	-

[1]Mean of 5 replications

[2]See Table 4, Appendix

[3]*, significance at the 5% level
ns, nonsignificant

[4]LSD, least significant difference at the 5% level

Table 3-Results[1] for cooking losses, moisture, ether extract and thiamin contents of baking hens.

	Cooking Loss %	Ether Extract %	Moisture %	THIAMIN Cooked Meat mcg/g	Moisture-Fat Free Meat mcg/g
Treatments[2]					
Microwave					
Untreated	28.5	6.5	64.9	.73	2.7
.000% papain	27.9	7.0	64.5	.91	3.3
.001% papain	30.3	6.5	64.0	.75	2.6
.002% papain	29.6	5.7	63.0	.80	2.6
Conventional					
Untreated	28.3	7.7	62.9	.64	2.2
.000% papain	29.5	6.6	64.8	.82	2.9
.001% papain	28.9	7.2	64.6	.78	2.7
.002% papain	29.9	6.2	65.0	.80	2.7
Significance of F-Value[3]					
Method	ns	ns	ns	ns	ns
Level	ns	ns	ns	ns	ns
Meth X Level	ns	ns	ns	ns	ns

[1]Mean of 5 replications
[2]See Table 4, Appendix
[3]ns, not significant

Thiamin was analyzed on a wet weight basis and also on a moisture and fat-free basis. On either basis, no difference was noted between microwave and conventionally cooked hens. Bowers and Fryer (1972) agree with those results in that type of oven, microwave or conventional, did not have any significant effect on the thiamin retention in turkey muscle. Thiamin content of untreated birds was not significantly different among birds that were injected with distilled water and both levels of papain (0.001 and 0.002%).

SUMMARY

Taste panel scores, Instron measurements, and thiamin, fat, and moisture contents from microwave and conventionally cooked baking hens, injected with distilled water and two levels of papain were determined using a randomized complete block design with five replications of each treatment. Moisture, fat, and thiamin contents along with cooking and thaw losses were not significantly affected by cooking method or injection. Less force was required to break the connective tissue between pectoralis major fibers of papain-injected hens ($P<0.05$). For measurement of fiber strength, no significant differences were observed. Papain injected samples were more tender to panelists than those without injection. The injected samples also had less roast chicken flavor ($P<0.05$), and off-flavor increased ($P<0.001$) with the increase in the level of papain injection. The mealiness of the samples increased ($P<0.05$) in the conventionally cooked hens when papain was injected at the 0.001% level. The juiciness increased ($P<0.01$) in the microwave oven-cooked birds when the papain level increased from 0.001 to 0.002%. Generally there were no differences between the two cooking methods, microwave and conventional.

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APPENDIX

Table 4-Treatment assignment for cooking of baking hens.

Evaluation Period	Block (week)	Treatments[1]
1	1	M2, C1, M1, Mun
2	1	M0, C0, C2, Mun
3	2	M2, C1, M1, Cun
4	2	M0, C0, C2, Mun
5	3	M0, M2, M1, Cun
6	3	C0, C1, C2, Cun
7	4	M2, C1, C2, Cun
8	4	M0, C0, M1, Mun
9	5	C0, M1, C2, Cun
10	5	M0, M2, C1, Mun

[1]M0 = Microwave cooked, 0.000% papain
M1 = Microwave cooked, 0.001% papain
M2 = Microwave cooked, 0.002% papain
Mun= Microwave cooked, Untreated
C0 = Conventionally cooked, 0.000% papain
C1 = Conventionally cooked, 0.001% papain
C2 = Conventionally cooked, 0.002% papain
Cun= Conventionally cooked, Untreated

Form 1- Score card for evaluation of baking hens.

BAKING HENS

Name ______________________ Date ______________________

Place a line perpendicular to the scored line at the point which best describes your evaluation for the characteristic listed. Label each mark with the sample code number.

TENDERNESS

Extremely Tender	Moderately Tender	Slightly Tender	Neither Tender nor Tough	Slightly Tough	Moderately Tough	Extremely Tough

ROAST
CHICKEN FLAVOR

Extremely Intense	Very Intense	Moderately Intense	Slightly	Very Slightly	No

OFF-FLAVOR

Extremely Intense	Very Intense	Moderately Intense	Slightly	Very Slightly	No

JUICINESS

Extremely Juicy	Moderately Juicy	Slightly Juicy	Neither Juicy nor Dry	Slightly Dry	Moderately Dry	Extremely Dry

MEALINESS

Extremely Mealy	Very Mealy	Moderately Mealy	Slightly Mealy	Very Slightly Mealy	Not Mealy (Adhesive)

THIS BOOK CONTAINS NUMEROUS PAGES WITH DIAGRAMS THAT ARE CROOKED COMPARED TO THE REST OF THE INFORMATION ON THE PAGE.

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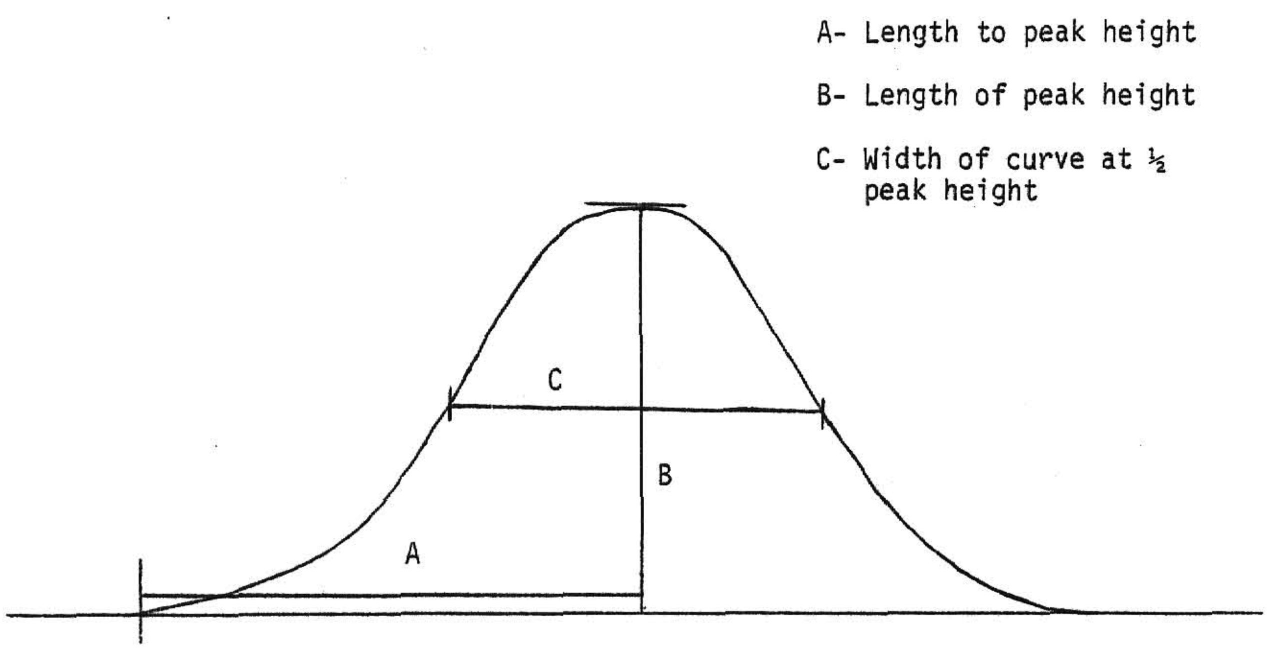

Fig. 1-Example of an Instron curve and measurements taken.

Table 5-Tenderness, mealiness, and juiciness scores[1] for baking hens.

Factor	Block 1	2	3	4	5	Mean
Tenderness						
Microwave						
0.000% papain	5.4	4.0	3.6	2.8	3.5	3.9
0.001% papain	3.4	4.4	4.6	-	5.6	4.5
0.002% papain	5.2	4.8	6.0	4.8	4.5	5.1
Conventional						
0.000% papain	2.5	4.5	2.6	2.8	4.0	3.3
0.001% papain	5.3	5.8	5.9	3.4	5.0	5.1
0.002% papain	5.1	4.9	5.3	4.2	3.9	4.7
Mealiness						
Microwave						
0.000% papain	4.3	4.2	3.3	3.4	3.8	3.8
0.001% papain	3.4	3.6	4.7	-	3.5	3.8
0.002% papain	4.4	3.9	4.7	3.6	3.3	4.0
Conventional						
0.000% papain	3.6	4.4	3.0	3.5	2.6	3.4
0.001% papain	4.7	4.9	4.0	3.9	3.8	4.3
0.002% papain	5.5	4.7	4.6	4.1	3.7	4.5
Juiciness						
Microwave						
0.000% papain	3.9	4.5	3.6	3.1	3.3	3.7
0.001% papain	2.6	3.6	3.2	-	4.1	3.4
0.002% papain	3.2	4.4	3.7	3.6	4.1	3.8
Conventional						
0.000% papain	3.3	3.9	3.5	3.0	3.8	3.5
0.001% papain	3.4	3.8	4.4	3.6	3.4	3.7
0.002% papain	3.1	3.7	3.3	3.4	3.6	3.4

[1]1, extremely tough, not mealy or extremely dry to 7, extremely tender, extremely mealy, or extremely juicy.

Table 6-Chicken flavor and off-flavor scores[1] for baking hens.

Factor	Block 1	2	3	4	5	Mean
Chicken Flavor						
Microwave						
0.000% papain	4.3	3.1	3.8	3.8	4.0	3.8
0.001% papain	2.8	3.8	3.6	-	3.6	3.5
0.002% papain	3.0	4.0	3.2	2.6	3.9	3.3
Conventional						
0.000% papain	4.2	3.7	3.9	3.6	3.4	3.8
0.001% papain	2.9	3.2	3.3	3.9	3.5	3.4
0.002% papain	3.5	3.6	3.4	3.4	3.6	3.5
Off-Flavor						
Microwave						
0.000% papain	2.8	4.2	2.8	2.7	2.5	3.0
0.001% papain	3.0	3.5	3.1	-	3.6	3.3
0.002% papain	3.4	2.7	3.6	4.9	3.2	3.6
Conventional						
0.000% papain	2.0	2.4	2.8	3.3	2.8	2.7
0.001% papain	3.6	3.4	3.5	2.2	4.0	3.3
0.002% papain	4.2	3.3	3.4	3.1	4.2	3.6

[1] 1, no chicken or off-flavor to 7, extremely intense chicken or off-flavor

Table 7-Measurements from Instron curves (cm) for muscle fiber.

Factor	Block 1	2	3	4	5	Mean
<u>Peak Height</u>						
Microwave						
0.000% papain	8.15	3.95	4.75	9.10	7.20	6.6
0.001% papain	11.00	4.85	2.45	6.45	6.50	6.3
0.002% papain	4.80	4.75	7.00	6.05	6.20	5.8
Conventional						
0.000% papain	4.45	5.05	5.25	5.50	3.50	4.8
0.001% papain	6.80	4.50	1.75	2.35	10.10	5.1
0.002% papain	5.65	5.20	4.40	3.10	6.15	4.9
<u>Distance to Peak Height</u>						
Microwave						
0.000% papain	1.50	2.75	3.50	1.85	1.80	2.3
0.001% papain	1.90	1.35	3.10	1.60	3.25	2.2
0.002% papain	1.30	1.50	3.60	1.95	2.45	2.2
Conventional						
0.000% papain	4.75	4.65	3.05	1.55	3.50	3.5
0.001% papain	1.40	1.40	1.45	4.00	2.85	2.2
0.002% papain	1.95	3.05	3.45	2.30	3.55	2.9
<u>Width at ½ Peak Height</u>						
Microwave						
0.000% papain	3.55	3.00	5.55	6.00	2.30	4.1
0.001% papain	1.45	2.85	3.65	2.00	3.85	2.8
0.002% papain	1.45	1.65	3.05	4.10	4.90	3.0
Conventional						
0.000% papain	10.00	5.50	3.05	4.48	3.65	5.4
0.001% papain	1.30	3.30	1.90	3.90	4.35	3.0
0.002% papain	2.25	2.10	3.50	2.15	8.25	3.7

Table 8-Measurements from Instron curves (cm) for connective tissue.

Factor	Block 1	2	3	4	5	Mean
Peak Height						
Microwave						
0.000% papain	10.65	7.25	6.05	5.50	5.00	6.9
0.001% papain	4.50	3.80	8.75	7.65	5.45	6.0
0.002% papain	6.25	5.25	7.50	6.25	10.45	7.1
Conventional						
0.000% papain	7.20	5.05	6.35	7.75	6.40	6.6
0.001% papain	4.65	2.65	3.70	4.00	5.80	4.2
0.002% papain	5.15	3.60	4.15	6.45	5.30	5.0
Distance to Peak Height						
Microwave						
0.000% papain	3.85	4.45	3.60	4.05	3.80	4.0
0.001% papain	1.50	3.55	2.65	5.30	3.20	3.2
0.002% papain	2.10	4.10	3.90	3.90	3.10	3.4
Conventional						
0.000% papain	3.25	4.45	4.35	5.95	5.00	4.6
0.001% papain	3.30	4.40	4.00	2.90	3.65	3.7
0.002% papain	2.75	2.95	1.85	4.70	3.35	3.1
Width at ½ Peak Height						
Microwave						
0.000% papain	3.70	5.20	6.15	4.20	4.50	4.8
0.001% papain	2.15	4.80	5.65	4.40	3.70	4.1
0.002% papain	5.10	4.70	5.10	6.85	10.55	6.5
Conventional						
0.000% papain	5.35	4.65	4.35	5.90	8.00	5.7
0.001% papain	4.85	4.10	4.85	3.60	4.15	4.3
0.002% papain	4.10	4.20	4.55	5.85	4.15	4.6

Table 9-Moisture and ether extract contents of baking hens.

Factor	Block 1	2	3	4	5	Mean
Moisture, %						
Microwave						
untreated	63.25	-	-	-	62.59	64.9
	66.67	66.43	-	65.67	-	
0.000% papain	66.12	64.68	66.99	63.34	61.30	64.5
0.001% papain	65.09	63.96	62.26	64.46	64.26	64.0
0.002% papain	63.38	58.61	65.01	62.49	65.45	63.0
Conventional						
untreated	-	65.53	59.93	62.70	-	62.9
	-	-	63.30	-	62.82	
0.000% papain	64.11	66.08	66.83	62.97	63.90	64.8
0.001% papain	62.96	64.53	67.22	63.47	64.94	64.6
0.002% papain	66.90	65.35	64.33	63.89	64.60	65.0
Ether Extract, %						
Microwave						
untreated	8.28	-	-	-	-	6.5
	6.76	5.39	-	5.99	6.14	
0.000% papain	5.80	5.77	5.86	6.85	10.79	7.0
0.001% papain	6.31	6.20	7.74	5,97	6.39	6.5
0.002% papain	5.79	5.84	6.11	5.72	4.98	5.7
Conventional						
untreated	-	6.42	7.83	8.61	8.80	7.7
	-	-	6.68	-	-	
0.000% papain	6.10	8.13	4.92	7.46	6.51	6.6
0.001% papain	7.90	7.23	4.40	8.27	8.37	7.2
0.002% papain	5.78	5.27	6.94	7.49	5.71	6.2

Table 10-Cooking losses of baking hens.

Factor	Block 1	2	3	4	5	Mean
Cooking Loss,%						
Microwave						
untreated	-	-	-	-	-	28.5
	25.46	29.63	-	23.31	35.57	
0.000% papain	24.36	24.30	29.56	30.92	30.25	27.9
0.001% papain	31.53	28.65	27.84	33.44	29.88	30.3
0.002% papain	34.13	28.03	-	29.98	26.08	29.6
Conventional						
untreated	-	-	30.08	29.26	27.73	28.3
	-	-	25.33	-	-	
0.000% papain	30.00	27.82	25.55	34.70	29.44	29.5
0.001% papain	26.63	24.42	30.25	29.76	30.65	28.3
0.002% papain	30.44	29.43	32.49	28.18	28.82	29.9

Table 11-Thiamin content of baking hens.

Factor	Block 1	2	3	4	5	Mean
Thiamin, mcg/g cooked meat						
Microwave						
untreated	.590	-	-	-	-	.73
	.730	0.61	-	1.21	.50	
0.000% papain	.825	0.735	1.20	0.92	.857	.91
0.001% papain	.640	0.96	0.77	0.84	.530	.75
0.002% papain	.530	1.10	1.01	0.50	.808	.80
Conventional						
untreated	-	.85	.36	.67	.523	.64
	-	-	.75	-	-	
0.000% papain	.93	.97	.82	.69	.705	.82
0.001% papain	.83	.78	.77	.71	.788	.78
0.002% papain	.63	1.05	.79	.70	.785	.80
Thiamin, mcg/g moisture-fat free meat						
Microwave						
untreated	2.00	-	-	-	1.60	2.7
	2.75	2.20	-	4.30	-	
0.000% papain	2.90	2.50	4.55	3.10	3.15	3.3
0.001% papain	2.25	3.30	2.65	2.80	1.80	2.6
0.002% papain	1.70	3.15	3.70	1.56	2.75	2.6
Conventional						
untreated	-	3.05	1.10	2.35	-	2.2
	-	-	2.65	-	1.85	
0.000% papain	3.10	3.75	2.95	2.30	2.35	2.9
0.001% papain	2.85	2.80	2.70	2.50	2.95	2.7
0.002% papain	2.30	3.60	2.85	2.45	2.65	2.7

THIAMIN CONTENT AND SENSORY EVALUATION OF POST-MORTEM PAPAIN-INJECTED CHICKEN COOKED IN MICROWAVE AND CONVENTIONAL OVENS

by

KENNETH JOHN PRUSA

B.S., Fort Hays State University, 1979

AN ABSTRACT OF A MASTER'S THESIS

submitted in partial fulfillment of the

requirements for the degree

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Taste panel scores, Instron measurements, and thiamin, fat, and moisture contents from microwave and conventionally cooked baking hens, injected with distilled water and two levels of papain solution (0.001 and 0.002%) were determined using a randomized complete block design with five replications of each treatment. Moisture, fat, and thiamin contents along with cooking and thaw losses were not significantly affected by cooking method or injection. Less force was required to break the connective tissue between fibers when papain solution was injected ($P<0.05$). For measurement of fiber strength, no significant differences were observed. Papain-injected samples were more tender than those without injection. The injected samples also had less roast chicken flavor ($P<0.05$) and the off-flavor increased ($P<0.001$) with the increase in the level of papain injection. The mealiness of the samples increased ($P<0.05$) in the conventionally cooked hens when papain was injected at the 0.001% level. The juiciness increased ($P<0.01$) in the microwave oven-cooked bird when the papain level increased from the 0.001 to 0.002% solution. Generally, there were no differences between the two cooking methods, microwave or conventional.