

## REFRIGERATION, FREEZING AND THAWING

Pl.

## EFFECTIVENESS OF ENZYMATIC TENDERIZATION OF BEEF IN MEETING CONSUMER DEMANDS

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Tenderness has been defined as that quality of cooked meat recognized by the characteristic of easy chewability without the loss of desirable texture. Factors influencing meat tenderness are not completely understood. Certainly the type and amount of connective tissue present and the muscle fibers are meat components important in determining meat tenderness. Chronological age, feeding and breeding are equally important and in general, younger well finished cattle will tend to be more tender. Rigor pattern, as well as factors affecting rigor are important but as yet their role in determining tenderness is not fully understood. Naturally occurring proteolytic enzymes have been isolated from muscle tissue and these no doubt play a role in the tenderness increase that results when meat is aged. However, in spite of these many known factors, the ability to provide uniformly tender meat by controlling or modifying these factors has not yet been fully achieved.

Studies have been conducted demonstrating that tenderness is by far the most important attribute of meat quality from the consumer standpoint. When asked if she were disappointed in the meat she had purchased, up to three-fourths of the consumers gave an affirmative answer. When asked to express a reason for her disappointment, toughness was by far the largest single cause for complaint. Recognizing this, the meat industry has attempted to improve tenderness through breeding, feeding, aging, cooking, mechanically and in more recent times through the addition of proteolytic enzymes.

Starting with research in the early fifties, a method was developed in which a proteolytic enzyme, papain, is introduced into the live animal shortly before slaughter. This approach was taken in order to achieve the uniformity of distribution afforded through employment of the circulatory system and results in level of approximately 5 ppm of enzyme in the meat tissue.

In order to measure the effectiveness of the ProTen process, consumer studies were conducted to evaluate overall consumer acceptance. These studies demonstrated that the tenderness increase achieved is significant at the 95% confidence level and is easily recognized by the consumer. Tests also demonstrated that as tenderness increased other meat quality attributes such as flavor and juiciness are also rated higher by the consumer.

This paper will review some of the tenderness studies that have been conducted and will also discuss results of studies measuring consumer reaction to tenderized meat.

## WIRKSAMKEIT DER ENZYMATISCHEN ZARTMACHUNG VON RINDFLEISCH UM KAUFERANFORDERUNGEN GERECHT ZU WERDEN

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Zartheit ist definiert als die Qualität vom gekochten Fleisch erkennbar mit der Charakteristik der leichten Kaubarkeit ohne Verfestigung des erwünschten Gefüges. Die Faktoren, die die Zartheit des Fleisches beeinflussen sind nicht völlig verstanden. Die Art und Menge von Fleischgeweben und Muskelsträngen sind gewiss wichtige Eigenschaften, die Fleischzartheit bestimmen. Das Alter, die Fütterung und Vermehrung der Tiere sind gleichermassen wichtig und wichtig, je jünger das Tier, desto zarter das Fleisch. Die Zartheit als auch die Faktoren, die diese Erstarrung hervorrufen sind bedeutend, aber ihre Rolle auf die Zartheit des Fleisches ist bis heute noch nicht ganz erforscht. Die in der Natur befindlichen proteolytischen Enzyme sind von den Muskelsträngen isoliert worden und diese Enzyme spielen zweifellos eine Rolle bei dem Zartheitsprozess, der bei Fleischlagerung stattfindet. Aber trotz dieser vielen, bekannten Faktoren ist die Möglichkeit eines immer zarter werdenden Fleisches zu erzeugen noch nicht vorhanden.

Studien sind gemacht worden, die zeigen, dass die Fleischzartheit vom Standpunkt des Käufers als wichtigste Eigenschaft vorzuziehen ist. Wenn gefragt wird, ob Enttäuschung beim Einkauf des Fleisches vorliegt, antworteten bis zu drei Viertel der befragten Käufer. Wenn weiter um den Grund der Enttäuschung gefragt wird, ist die Härte der Fleischindustrie anerkannt und die Forschung versucht durch Kreuzen, Fütterung, Lagerung und Zubereitung und in neuerer Zeit durch Zugabe der proteolytischen Enzyme die Zartheit mechanisch zu verbessern.

Mit der Forschung in den 50er Jahren ist ein Verfahren entwickelt worden, wobei ein proteolytisches Enzym, namens Papain, in das Fleisch dieser Verfahren noch lebende Tier eingespritzt wurde. Dieses Verfahren benutzt das Kreislaufsystem des Tieres um eine gleichmässige Verteilung des Enzyms hervorzuführen. Hieraus resultiert in Fleisch ein Enzymgehalt von ungefähr 5 ppm.

Kaufbefragungen wurden unternommen um die Kundenzufriedenheit mit der Wirksamkeit des PROTEN Prozesses zu beurteilen. Diese Befragungen ergaben, dass die durch diesen Prozess erzielte Zartheit vom Käufer leicht feststellbar ist und betrifft ein Vertrauensniveau von 95%. Versuche zeigen auch, dass bei der Erhöhung der Zartheit andere Qualitäten des Fleisches wie Geschmack und Saftigkeit hervortreten und werden vom Käufer besser beurteilt.

Die Ziele dieser Veröffentlichung werden einige Zartheitsversuche beschrieben, die sich mit der Reaktion der Käufer, denen das auf diese Weise zubereitete Fleisch vorgestellt war, befassen.

## L'EFFICACITÉ DE ATTENDRISEMENT ENZYMATIQUE DU BOEUF VIS-A-VIS LES DEMANDES DU CONSOMMATEUR

La tendreté de la viande a été défini comme cette qualité qu'on reconnait comme la facilité de macher sans perte de texture. Les facteurs qui influencent la tendreté de la viande ne sont pas complètement connus. L'âge, la nourriture et la race de l'animal ont une importance similaire, et en général le bétail le plus jeune et le mieux fini sera le plus tendre. Le patron de rigueur aussi bien que les facteurs qui affectent la rigueur sont importants, mais jusqu'aujourd'hui leur rôle n'est pas complètement compris. Des enzymes protéolytiques naturels ont été isolés des muscles, et il y a aucun doute que ceux-ci ont un rôle important dans l'attendrissement de la viande vieillie. Cependant, en dépit de tout les facteurs connus, on n'a pas encore pu obtenir une tendreté uniforme en contrôlant ou modifiant ces facteurs.

Des études ont été faites qui démontrent qu'au point de vu de la consommatrice la tendreté est la qualité de la viande la plus importante. Quand on lui demandait si elle était désappointée avec la viande qu'elle avait achetée les trois-quarts répondaient affirmativement. Quand on demandait la raison pour son désappointement, la plupart donnait la dureté de la viande comme la plus fréquente cause. Reconnaisant ceci l'industrie de la viande a essayé d'améliorer la tendreté par; l'élevage, la nourriture, le vieillissement, la cuisson, par moyens mécaniques, et plus récemment par l'additionnement d'enzymes protéolytiques.

Commencant avec des investigations faites vers mil neuf cent cinquante, une méthode fut développée dans laquelle une enzyme protéolytique, la papaine est introduite dans l'animal quelques minutes avant de le tuer. Ceci permet d'obtenir une uniformité de distribution utilisant le système circulatoire de l'animal pour obtenir un niveau de 5 ppm de l'enzyme dans la viande.

Pour mesurer l'efficacité du procédé ProTen, des études ont été faites chez le consommateur pour déterminer son acceptation. Ces études ont démontrées que l'augmentation de tendreté est significative à un niveau de confiance de 95% et que celle-ci est facilement reconnue par le consommateur. Ces tests ont aussi démontrés qu'en obtenant une augmentation dans la tendreté de la viande le consommateur pouvait aussi noter, en même temps une amélioration d'autres qualités telles que la saveur et la quantité de jus dans la viande.

Cet article passe en revue quelques unes des études faites sur la tendreté de la viande et décrira les résultats obtenus sur des études faites pour mesurer la réaction du consommateur vis-à-vis la viande attendri.

## ЭФФЕКТИВНОСТЬ ФЕРМЕНТНОГО СМЯГЧЕНИЯ ГОВЯДИНЫ КАК СРЕДСТВА УДОВЛЕТВОРЕНИЯ ЗАПРОСОВ ПОТРЕБИТЕЛЯ

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Мягкость определяется как свойство приготовленного мяса, проявляющееся в лёгкой прожёвываемости без потери желаемой фактуры. Факторы, влияющие на мягкость мяса, не вполне понятны. Несомненно, вид и количество содержащейся соединительной ткани и мышечных волокон - компоненты мяса, важные для определения его мягкости. Хронологический возраст, откорм и разведение равно важны, и, вообще говоря, мясо более молодого, правильно забитого скота имеет тенденцию быть мягче. Явление окоченения, так же как и факторы, на него влияющие, важны, но их точная роль в определении мягкости не вполне понятна. Встречающиеся в природе протеолитические ферменты были выделены из мышечной ткани и играют несомненную роль в повышении мягкости мяса при выдерживании. Тем не менее, несмотря на такое обилие известных факторов, возможность производить равномерно мягкое мясо путём управления этими факторами и их модификации не вполне достигнута. Были проведены исследования, показавшие, что мягкость далеко превосходит все остальные качества мяса по важности с точки зрения потребителя. На вопрос, разочарованы ли они купленным мясом, более трёх четвертей потребителей дали утвердительный ответ. В ответ на просьбу указать причину разочарования, значительное большинство потребителей указало в качестве такой причины жёсткость. Приняв это к сведению, мясная индустрия предприняла усилия к увеличению мягкости при помощи воздействия на разведение, откорм, выдерживание, готовку, механическую обработку и, более недавно, - при помощи добавления протеолитических ферментов.

Начавшись в начале пятидесятых годов, постепенно был разработан метод введения протеолитического фермента папаина в живое животное незадолго перед убоем. Такой подход был применён с целью достижения равномерности распределения, достигавшейся путём использования системы кровообращения, и приводит к уровню в приблизительно 5 ppm фермента в мясной ткани.

Для измерения степени эффективности этого процесса, называемого ПроТен, были проведены исследования потребителя, имевшие своей целью определение общей реакции последнего. Эти исследования показали, что достигнутое повышение мягкости может быть охарактеризовано как значительное, со степенью надёжности в 95%, и легко различается потребителем. Проверки показали также, что с ростом мягкости и другие показатели качества мяса, такие как аромат и сочность, также были оценены потребителем как более высокие.

Эта работа рассмотрит некоторые из проведённых исследований мягкости, а также оценит результаты исследований по измерению реакции потребителя на смягчённое мясо.

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Tenderness has been defined as that quality of cooked meat recognized by the characteristics of easy chewability without the loss of desirable texture. Factors influencing meat tenderness are not completely understood. Certainly the type and amount of connective tissue present as well as the muscle fibers are meat components important in determining tenderness. Chronological age, feeding and breeding are equally important and in general younger well-finished cattle will tend to be more tender. Rigor pattern as well as factors affecting resolution of rigor are important but as yet their role in determining tenderness is not fully understood. Naturally occurring proteolytic enzyme have been isolated from muscle tissue and these no doubt also play a role in tenderness, particularly that tendering we see occurring as meat is aged. However, in spite of these many known factors, the ability to provide uniformly tender meats by controlling or modifying these factors has not yet been fully achieved.

Studies have been conducted demonstrating that tenderness is by far the most important attribute of meat quality from the consumer standpoint. When asked if she were disappointed in the meat she had purchased, up to three-fourths of the consumers gave an affirmative answer. When asked to express a reason for her disappointment, toughness was by far the largest single cause for complaint. Recognizing this, the meat industry has attempted to improve tenderness through breeding, feeding, aging, cooking, mechanically and in more recent times through the addition of proteolytic enzyme. In the latter case, the enzymes have been added to meat cuts either by dipping meat cuts in a solution of proteolytic enzyme or by injecting the enzyme into the meat using various pumping systems. While these methods have been relatively successful, their success has been limited since both dipping and injecting results in relatively poor distribution, a lack of uniformity in tenderness, and often times, mushiness or overtenderization.

Recognizing the limitations of existing tendering systems our research staff commenced work in the early 1950's to develop a method for providing uniform tenderness. The approach that was taken considered the fact that by utilizing the circulatory system we could indeed achieve uniform distribution throughout the meat tissues. After considerable research, including investigation of various proteolytic enzymes, papain, derived from the tropical papaya fruit, was selected. Papain provides the best overall tendering of any of the enzymes tested. Through use of specific biochemical techniques we are able to control its action eliminating problems of animal reaction resulting from introduction of a foreign protein into the blood stream. In order to

As our studies continued, it became important to know whether or not the consumer, like the expert, could recognize the tenderness increase achieved with the pretendering process. Numerous studies were conducted, first in our consumer test kitchens and later through home-placement tests. As an example, in our consumer test kitchen consumers were provided with samples of three sirloin tip roasts. The sirloin tip was selected since it is frequently troublesome to the homemaker because of toughness. One of the samples was from an untendered control, one from beef that had been pretendered (ProTen) and the other from a competitive method of tendering meat. These studies are summarized in the following table.

Consumer Ratings - Tenderness	Sirloin Tip Roast
Treatment	Tendering Rating
Control	4.5
Competitive Method	4.4
ProTen	7.5

Based on 10 Point Scale Where 10 = Very Tender, 1 = Very Tough.

Obviously, the tenderness increase, amounting to three points on a ten point scale, was highly significant and demonstrated that the consumer could easily recognize the tenderness increase achieved with ProTen.

In another study, consumers were provided with three samples of roasts. One of these was a ProTen chuck roast (shoulder), one a non-tenderized chuck roast and the third was a non-tenderized rib roast. The chuck roast was selected because it is usually recognized as a tough cut and requires long, slow, moist-heat cooking in order to provide eating satisfaction. The rib-roast from non-tendered cattle was selected since it is considered to be a relatively tender cut of meat that can be oven-roasted (dry heat). Consumers were asked to oven-roast all three cuts of meat since this is the traditional cooking method for the preparation of a tender cut of meat. Results of these studies are demonstrated in the following table.

Table III  
Comparison of ProTen Chuck and Regular Rib and Chuck Cooked with Dry Heat

Characteristic	Regular Beef		
	ProTen Chuck	Chuck	Rib
Tenderness	8.8	6.1	8.5
Flavor	7.8	7.2	7.4
Juiciness	7.8	7.7	7.5
Over-All	7.9	6.5	7.8

Based on 10 Point Scale Where 10 = Very Tender and 1 = Very Tough

You will note that the ProTen chuck roast, was equal in tenderness to the rib roast and superior to the non-tendered chuck roast. This again demonstrated that the tendering process was effective and that the tenderness increase that was observed by the expert panels was also recognized by the consumer.

Following our consumer panel tests, we embarked upon a program of store testing. The purpose of these tests were to deter-

assure that the enzyme introduction had no effect on the live animal numerous studies were conducted. These studies included blood chemistry, histology, and hormonal studies to name a few. In addition, numerous tendering studies were required to demonstrate the effectiveness of the process. The result of this overall research program was culminated with granting of the approval to use the pretendering process by the United States Department of Agriculture in 1959. The use of papain as a tendering enzyme is fully approved by the Food and Drug Administration, United States Department of Health, Education and Welfare. Papain, of food origin, is derived from the papaya fruit and has a long history of safe usage.

In the process the live animals are first graded, sorted, and brought to a special processing room designed to provide for food sanitation. The animals are placed in a restrainer, and their head turned to one side using a rope halter. The animal is then weighed, the neck area cleaned and, using food veterinary practice, a needle inserted into the jugular vein. Then, based on the animals grade, weight, the enzyme solution is automatically metered to the live animal. The amount of enzyme solution introduced is approximately 80 milliliters for a 1000 lb. U.S. Choice steer and results in a level of 5 to 10 parts per million in the meat tissue. Following processing the animal is released and slaughtered in the normal manner. We require that an animal be held a minimum of two minutes and a maximum of 30 minutes from time of injection to slaughter. This is merely to provide for uniform distribution of the enzyme.

Today I would like to share with you some of the tendering studies that have been conducted over the years including consumer research studies which demonstrate the viability of the process and its importance in providing uniformly tender meat for the consumer.

Throughout the development numerous tenderness tests were conducted. One of the more significant studies was that conducted under the supervision of the Meat Inspection Division of the United States Department of Agriculture. These studies are summarized in Table I and resulted in granting of approval for the process by the Department of Agriculture. It also permitted us to label the product "Tendered with Papain."

Enzyme Level	STEAKS		ROASTS		Good Grade
	Commercial Grade	Good Grade	Commercial Grade	Good Grade	
None	5.4	6.8	7.2	8.9	8.9
Suboptimum	6.0	7.7	8.2	9.3	9.3
Optimum	6.5	8.1	9.0	9.5	9.5

Based on 10 Point Scale Where 10 = Very Tender and 1 = Very Tough

mine whether the consumer could detect the improvement in tenderness of beef merely by substituting it, unidentified, for the beef she was accustomed to buying. Through the use of in-depth interviews, we were able to detect changes in attitudes toward the beef being purchased. We asked the consumer when she had last served beef, what item was served, and how it compared with other previous purchases. She was asked to state whether it was the same, better, or not as good as meat she usually purchased from this store. An example of the data developed, using this technique, is demonstrated in the following table.

Attribute	Control	ProTen
Tenderness	22%	48%
Flavor	20%	38%
Juiciness	18%	35%

One of the interesting discoveries that came out of this series of tests was the fact that other attributes of ProTen beef, namely, flavor and juiciness were also rated higher by the consumer. This in spite of the fact that laboratory studies have demonstrated that the tendering process has no effect on juiciness and flavor. Obviously, to the consumer, when meat is tender its eating quality is improved in all respects.

In these early studies, we also investigated consumer attitudes toward ProTen Beef. Using interview techniques, women were told about the process and the benefits to the consumer and asked whether they would be interested in buying the beef. Two-thirds of the consumers having no experience were ProTen indicated they would definitely want to try it. Better than nine out of ten expressed some interest in trying ProTen. Among users, three-fourths expressed a definite purchase interest and an additional twenty percent said they were interested in buying occasionally or may try it again. When users reported their experience with the ProTen, 89% of those interviewed expressed satisfaction with the product. You will recall that in the beginning of this paper, studies by University of Missouri were cited indicating that 3/4 of the consumers were dissatisfied.

These studies also pointed out the importance of providing the consumer with additional information about ProTen, the process, and the benefits. This led to an overall marketing program including extensive programs to educate the consumer. Point of purchase materials, news media, recipe booklets and cooking schools were utilized to tell the story. Special cutting and chandising procedures were developed to take advantage of the tendered tenderness. This resulted in a greater utilization of the carcass, with more cuts being acceptable for steaking and oven-roasting. The general theme was "guaranteed tenderness," a theme that has continued to be used even today.

We have continued to conduct consumer studies using similar in-depth interview techniques in various markets throughout the country. In general ProTen is recognized as a high-quality beef of beef. It tends to be rated favorably on all dimensions of

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ty, particularly on tenderness. Customers at stores purchasing ProTen beef in general reflect a high degree of satisfaction and stores carrying ProTen beef rate consistently higher than stores carrying competitor brands of beef.

We have also continued to monitor the program using expert panels. Recently we compared ProTen with U.S. Choice beef and a competitor brand marketed under a guaranteed tender program. Using a panel of 8 judges, trained and experienced in evaluating quality of meat, tenderness, and texture, samples of T-Bone Steaks, Round Roasts and Chuck Roasts were submitted for evaluation. In all instances, ProTen Beef cuts were judged more tender (95% level of significance) than either U.S. Choice or a competitive product merchandised under a guaranteed tender program.

Table V

Product	Tenderness Study - ProTen Vs. Competitive Brands		Competitive
	ProTen	U.S.Choice	
	Steak	8.72	
Round Roast	8.89	7.32	6.92
Chuck Roast	8.71	7.62	7.59

Based on 10 Point Scale Where 10 = Very Tender, 1 = Very Tough

While the process is utilized principally in the United States and the United Kingdom, our studies demonstrate that it is applicable throughout the World. Both commercially and on a test basis the process has been effectively demonstrated in Europe, Australia, Japan, and South America. In a recent study, conducted in Eastern Europe, the following highly significant tenderness response was obtained.

Table VI

Eastern Europe  
Tenderness Studies - Brisket

Type of Animal	Trained Panel		Consumer Panel	
	Control	ProTen	Control	ProTen
Heifer		5.0	4.0	5.0
One Calf Cow	2.0	4.8	1.4	4.0
Old Cow	2.4	4.7	1.4	4.0
Cows 3-4 Years	1.9	4.8	---	---
Cows Over 4 Years	2.3	4.6	---	---

Based on 5 Point Scale Where 5 = Very Tender

Table VII

Eastern Europe  
Tenderness Studies - Silverside

Type of Animal	Trained Panel		Consumer Panel	
	Control	ProTen	Control	ProTen
Heifer	2.5	4.8	3.7	5.0
One Calf Cow	3.6	4.8	1.5	4.1
Old Cow	2.9	4.0	1.5	1.9
Cows 3-4 Years	2.4	4.7	---	---
Cows Over 4 Years	2.1	4.7	---	---

Based on 5 Point Scale Where 5 = Very Tender.

The process is applicable to all species. While the data presented here has been on beef cattle, experimentally and for quality control purposes, we routinely process aged ewes. In addition, earlier studies have demonstrated that the process is equally effective on hogs and turkeys.

The growth of the process has been steady. Starting with the first introduction of the process in 1959 there has been a steady increase in the number of animals tendered. Today we are pre-tendering beef at all our major plants and ProTen in the neighborhood to 700,000 cattle annually. This amounts to approximately 40% of our total slaughter operations and 2.5% of the total U.S. slaughter.

ProTen has a distinct advantage over other methods of tendering meat:

1. It provides a method for guaranteed tenderness without the disadvantages associated with aging and other tendering methods.
2. Utilizes an enzyme (papain) derived from food source, the papaya.
3. Uniform enzyme distribution is achieved resulting in increased tenderness of all cuts of meat.
4. Has no effect on flavor, appearance or keeping quality.
5. There is a greater utilization of the carcass with more cuts tender enough to permit steaking and oven-roasting.

In this brief paper we have attempted to demonstrate the effectiveness of the ProTen process and in particular to point out the fact that through consumer studies we can demonstrate increased consumer satisfaction. Indeed, ProTen has gone a long way toward meeting the consumer demand for more tender beef.