ABSTRACT

PROPOSED SELF-INSTRUCTIONAL UNIT FOR TEACHING CONCEPTS OF HEAT APPLICATION TO RED MEATS

By

Sandra Lynn Smith

The purpose of this study was to investigate self-instructional techniques suitable for teaching concepts of heat application to red meats. These techniques were then utilized to prepare a unit of study for use in an undergraduate food preparation course requiring a chemistry prerequisite. Also, an evaluation of the unit of study was planned.

Behavioral objectives in the areas of knowledge, comprehension and application were developed for the unit. These objectives designated the terminal behavior expected of students upon completion of the unit.

Various approaches, techniques and materials for implementing a self-instructional program were reviewed. Tape recordings and 2 x 2 in. slides were selected as the most efficient and effective modes of instruction to achieve the specified behavioral objectives. A survey of commercial producers of audio-visual and instructional materials

indicated that in a specialized area, such as heat application to red meats, suitable prepared instructional materials are unavailable. Therefore, suitable materials were developed.

To explain the principles and concepts of heat application, twelve subunits were developed. These begin with a review of the composition of meat followed by a study of the effects of heat on protein structure and the individual meat components; muscle protein, connective tissue, color pigment, fat, water, vitamins and minerals, and bone. In the concluding three subunits, meat is considered as an integrated whole and the effects of various cooking methods, times and temperatures on the quality of cooked meat is studied.

A plan for evaluation of the self-instructional unit, including a pre- and post test was proposed. The difference in the number of correct responses for each behavioral objective between the pretest and post test is to be analyzed to assess attainment of the behavioral objectives.

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By

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INTRODUCTION

Teaching has been defined by Deterline (1962) as "the performance of those activities, and the manipulation of those conditions, that produce learning." A good method of teaching, according to McCluskey (1949), "provides a variety of learning experiences because we know that interest must be maintained if effective learning is to take place and that variety defeats monotony."

The self-instructional approach offers the possibility of efficiently incorporating student experiences to produce learning. Short et al. (1969) developed and evaluated a self-instructional beginning foods laboratory course to replace conventional laboratory demonstrations and explanations. Their results confirmed that a self-instructional approach can replace teacher lecture-demonstration type of laboratory instruction. Johnson et al. (1969) observed that performance of students taught by self-instruction was more consistent than when traditional teaching methods were employed. The value of instructional media is also emphasized by Gagne et al. (1959) who stated "... high amounts of positive transfer may be obtained by representations of stimulus objects. This means that the stimuli to be associated in the learning situation can be pictured, rather than 'real', without great losses in transfer...."

Self-instruction offers the advantage of allowing students to progress at their own pace and repeat materials as often as needed for comprehension. In addition, material which is already understood by the student may be by-passed while, at the same time, be available to students for review and/or make-up. Utilizing this approach insures optimum conditions for learning. Moreover, Deterline (1962) credited self-instruction with increasing teacher efficiency by eliminating some routine work, thereby freeing the teacher for discourse with students. In summarizing the results of several studies, Lysaught (1968) indicated students using self-instruction "did one of three things: a) learned appreciably more than their colleagues in terms of achievement and/or testing; b) learned comparable amounts in significantly less time more efficiently; c) tended to become more motivated or more responsible for their own learning."

Effective self-instructional programs are developed to fulfill the behavioral objectives of a course of study (Deterline, 1962). For some programs, the limited existing materials may be incorporated with or without adaptations (Short _et al_., 1969). It was the purpose of this study to investigate self-instructional techniques and materials suitable for teaching concepts of heat application to red meats and to utilize these techniques and materials to prepare exemplary materials for use in an undergraduate food preparation course requiring a chemistry prerequisite. Also, an evaluation of the unit of study was planned.

REVIEW OF LITERATURE

A review of recent literature indicated approaches to self-instructional curricula are numerous. These will be reviewed along with some of the various materials used for self-instruction. Finally, studies comparing the effectiveness of self-instructional methods with traditional teaching will be discussed.

Self-instructional Approaches

The Seminar/Autolecture or S/A system developed by Berman (1968) approaches self-instruction by semi-automating the routine aspects of teaching. For this system, a lecture is composed, edited and finally recorded in a manner which would be used for tutoring only one student. The lecture is then presented to individual students or to small or large groups of students. Following the autolecture, students meet in small-group seminars with the instructor for discussion of questions. With this approach, the self-pacing aspects of self-instruction are enhanced by using carrels for independent re-study of autolectures.

According to Banister (1968), Mt. San Jacinto College in California has replaced many of their routine lectures with multi-media instruction. In their typing and shorthand classes, for example, all routine instruction is presented by tape so the teacher is free to give individual help to students. In other classes, taped instruction is followed by seminar- or discussion-type learning situations.

Postlethwait (1969) discussed an audio-tutorial system which he used for teaching introductory botany. His program consisted of three study sessions per week; 1) an independent study session, 2) a general assembly session and 3) an integrated quiz session. For the independent study session, tapes and appropriate material for a week's study were made available for the student to use at his own pace and at a time of his own choosing in a campus learning center. The general assembly session was scheduled on a weekly basis and was utilized for showing long films, presenting guest lectures or administering tests. The integrated quiz session was based on the principle that "the first time one really learns a subject is when one teaches it." Therefore, in a small group situation each student was faced with the items about which he learned in the independent study sessions and he then identified the item, related the item to its appropriate objective and "taught" about it. Appropriate related activities such as long-range experiments were incorporated into the program for additional learning experiences.

Sisler (1970) reported the development of a three-phase audiotutorial system for teaching a beginning clothing course.

A lecture, independent study session in the audiotutorial laboratory and a quiz session were conducted each week. New material was introduced in the lecture, then the material was studied via slides, filmstrips, displays, tapes and question sheets in the audiotutorial laboratory prior to the quiz session in which weekly lessons were discussed and quizzes administered.

Self-instruction to train students to operate standard audio-visual equipment has been reported in the literature (Rothenberg, 1967). A progressive type of format was used in which the various pieces of equipment studied were in turn used as teaching devices. For example, the operation of a tape recorder was learned by means of a flip chart and phonograph; the tape recorder was then used to run an instructional tape informing the student how to operate the slide and filmstrip projector. This procedure continued through all pieces of equipment included in the course of study.

Behrens _et al_. (1967) described an auto-tutorial carrel system combining audio and visual media to successfully present adjunct materials in agricultural courses. Tapes, 2 x 2 in. slides and 8mm film loops were incorporated into the system. Listed as advantages of the system were one-time preparation, individually paced study, use of classroom time for discussions and coverage of additional materials for gifted students.

A self-instructional laboratory to replace conventional laboratory teacher lecture-demonstrations in a beginning foods course was designed by Short _et al_. (1969). Students studied tapes, slides, filmstrips, filmloops, displays and/or wall charts to familiarize themselves with terminology, manipulative skills and identification of standard products immediately prior to entering the laboratory. A pretest was administered to all students at the beginning of the course and based upon pretest performance, students were excused from any self-instruction laboratory for which they had demonstrated adequate knowledge. A post-test was administered following completion of a unit to insure student comprehension of the material.

Self-instructional units have been prepared without the development and production of many special materials according to a report by Menne _et al_. (1969). In an introductory psychology course, students were effectively taught by listening to tape recordings of regular lectures and studying booklets containing the material normally presented on the chalk board. In this system, recordings as well as booklets were available for re-study by the students.

In medical education, extensive and varied utilization of self-instruction was evident. Garcia _et al_. (1968) discussed the use of the Videosonic System, which employs a tape cartridge synchronized with a cartridge of color film slides, to present the features of a biochemical laboratory technique. The single-topic programs presented background knowledge on the operation of laboratory equipment.

Fiel (1968) reported the development of multi-media self-instructional materials designed to provide students with appropriate skills and orientation prior to actually conducting laboratory experiments. Programmed texts have been developed for training medical personnel in subject-matter areas of diabetic acidosis (Azneer *et al*., 1968), cancer of the colon and rectum (Bush, 1968), psychiatry (Mathis *et al*., 1968) and lactation (Claxton, 1968).

Various self-instructional approaches enhance medicine's continuing education program according to a report of Markee (1968). One approach provided doctors with television programs covering subject-matter areas of current significance. The participating physicians also received extensive outlines and summaries of the programs for permanent reference. Another self-instructional program provided participating hospitals with video-taped programs which may be used *ad libitum*. One- and two-way radio conferences and telephone-dial-access tape recordings also provided self-instructional opportunities for the medical profession.

Self-instructional Materials

In general, the production of a self-instructional unit necessitates the utilization of some form or forms of media. These media may be audio or visual in nature or a combination.

A brief review of the characteristics of each type follows. No attempt will be made to describe production of these materials since directions may be found in many audio-visual texts or obtained from local audio-visual centers.

Brown et al. (1969) discussed five types of graphics; cartoons, posters, graphs, charts and diagrams, as well as maps and globes. Each type relies on some form of symbolism to convey meaning; therefore, the authors suggested care must be taken in preparation of these graphics to avoid misinterpretation by the viewer.

Filmstrips, black and white or in color and with or without sound, are readily incorporated into a self-instructional unit when small compact projectors are used. Extensive lists of both the advantages and disadvantages of using filmstrips are compiled by Brown et al. (1969), Wilhelm (1968) and Cypher (1968).

Because of their compact size and ease of use, continuous loop films, either standard 8mm or Super 8, are incorporated into self-instructional units when visual motion is desired. Film loops are especially useful when slow-motion, time-lapse or microscopically viewed activities are desired (Eggenberger, 1967). Descriptions, potentials and costs of Super 8 films with either magnetic or optical sound tracks are discussed by Tubbs (1968) and Kreiman (1968). Kemp (1968) reviewed the planning as well as developmental processes of producing films for specific courses while

Przekop (1970) discussed uses of commercially prepared and self-produced film loops for science instruction. According to the latter author, an instruction design strategy for commercially prepared film loops is based on 1) statement of instructional objectives for the unit, 2) analysis of film content, and 3) supplementation of film content coverage.

Two by two in. slides are conveniently and frequently used to present visual material in self-instructional systems. According to reports, slides are used in self-instructional units in agriculture (Behrens _et al_., 1967), teacher-training (Rothenberg, 1967) and medicine (Lloyd, 1967; Fiel, 1968; Harden, 1968).

The use of sound in conjunction with film was mentioned. When only audio techniques are desired, reel or cassette tape recordings have been employed for instruction in psychology (Menne _et al_., 1969), teacher-training (Rothenberg, 1967), general education (Berman, 1968; Banister, 1968), agriculture (Behrens, 1967) and medicine (Fiel, 1968; Garcia _et al_., 1968; Graves, 1968; Harden, 1968).

Other media which have been incorporated into a limited number of self-instructional units include television and video tapes (Brown _et al_., 1968; Allen, 1967; Ramey, 1968; Potts, 1968). Also, computers have been included in some self-instructional systems (Reinecke, 1968; Fonkalsrud _et al_., 1968; Geis, 1967; Grubb, 1967).

Comparison of Self-instructional Methods with Traditional Teaching

A review of the literature indicated that while there is much interest in and development of self-instructional materials, definitive evaluation of these materials is limited. Moreover, subjective opinions of students as well as instructors rather than empirical data comparing the two methods of teaching predominated in the literature. The results of four empirical studies will be reviewed followed by a summary of the subjective findings of other studies.

Menne et al. (1969) compared scores on regular exams, total class points and final grades of college undergraduates taught introductory psychology by two methods, traditional live lecture and taped lecture. The results of their study indicated taped lectures can be as effective as traditional teaching methods in supplying information to college undergraduates. In addition, they found student reaction to taped lectures was favorable. According to their report

> ... the use of tapes resulted in their (students) spending as much (65%), or more (35%) time on the course than they would have otherwise; 68% thought they had learned as much or more, 32% thought they had learned less; 70% said they would recommend Psychology 101 taped lectures to other students, 30% said they would not; 52% said they would prefer other tape lecture presentations to large lecture sessions. Most of the (experimental group) were appreciative of the freedom and flexibility which the method allowed them, though many of them admitted that procrastination frequently led to many hours of concentrated listening just prior to exams; 51% ... reported listening to the tapes no more than once each.

Fiel (1968) used a self-instructional unit to prepare students (Preparation Laboratory) for a laboratory session (Action Laboratory) in physiology. In his evaluation he concluded

> 1. Student setup time in the Action Laboratory was reduced by approximately one hour.
> 2. Student interest, attitude, and appreciation for the course were greatly improved.
> 3. Students were overwhelmingly in favor of the development of a Preparation Laboratory for another physiology course.
> 4. Students felt Preparation Laboratories would be a valuable addition to many other science courses.

Differences in effectiveness of learner-centered, teacher-centered and no-instructor methods of instruction for a course in general psychology was evaluated by Rubadeau (1968). He found

> ... no significant differences on criterion measures of effectiveness; however, on the criterion measure of efficiency, the learner-centered learning students learned significantly faster. When students were categorized on the basis of preference for instructional mode, no significant differences were found. High ability students performed significantly better than low ability students on all measures of effectiveness and efficiency as expected. There was, however, no significant difference in performance between high or low ability students under one instructional mode and those instructed by the other instructional modes. Learner-centered instruction emerges as a viable, and an interesting, alternative to traditional forms of teaching.

Johnson *et al*. (1969) compared the effectiveness of a programmed self-instructional unit with traditional teacher-taught methods for teaching skills in different sections of a beginning clothing construction course. The five evaluation devices indicated large differences between the teacher-taught and program-taught sections with the latter being superior. In addition, the authors commented that more consistent performance was noted in students taught by self-instructional programs.

Berman (1968) cited the "placebo" effect and the inability to "exactly duplicate subject matter and emphasis in two test groups for inclusion or exclusion on examinations" as the reason for not statistically evaluating his Seminar/ Autolecture system. Rather, he has tried his method in a variety of classes and situations and compared the number of students favoring the S/A system to the number favoring the previously used teaching method. He also considered the number of students having no preference for a teaching method. In general, he reported more students favoring his S/A system.

In all instances where self-instructional approaches were tried, they were considered an improvement over previous teaching methods, in terms of teaching efficiency as well as student acceptance. Postlethwait (1969), in evaluating self-instruction in a college botany course stated

> The results have been highly gratifying and stimulating from every point of view. The students are enthusiastic; and in many cases have encouraged other instructors to embark on a similar program. Grades have improved so that many colleagues are pleased with the amount of progress. The level of staff and general costs are somewhat less than under the conventional system. The system breaks the lock-step approach of the conventional system so that students can pace themselves.

In a general discussion of the importance of recorded communication, Allender (1967) stated

> When human contact is not important, instructional materials can provide more efficient teaching than that usually done by a teacher, simply because they can be used over and over again. Their continued use justifies costly preparation. The result is more free time for the teacher which can, among other possibilities, be used for more individualized instruction.

Behren *et al*. (1967), in assessing the value of self-instructional units in courses in agriculture, found students enthusiastically in favor of the new approach. The course instructor also believed the "materials assisted instruction and presented a valuable channel for communicating knowledge." In referring to the efficiency of this teaching method, the authors observed

> The main advantages of this system are one-time preparation and individual study. The instructor can make a more thorough presentation of subject matter and can make corrections before presenting the material. Demonstrative material can be prepared outside the classroom once and presented repeatedly, and events controlled by biological timing can be presented at any time. Students can cover the material at their most efficient pace, even repeating if necessary, and they have unobstructed viewing. Classroom time is freed for discussion. Updating the material is a simple procedure. Finally, the system provides a framework for coverage of additional objectives for gifted students.

Rothenberg (1967), in evaluating a self-instructional laboratory for training students to operate audio-visual equipment, reported

> ... a study was made of students who completed the program, indicating that there is good retention of information and good transference of learning to other machines. In addition, we have found that students who have used the facilities of Self-Instruction Laboratory display a keen interest in the program and achieve self-confidence in the use of audio visual machinery.

PROCEDURE

The self-instructional unit on the concepts and principles involved in the application of heat to red meats was developed as an integral part of a potential undergraduate course in food preparation. A topic outline for the course is presented in Figure 1. In the area of consideration of meat as a protein food system, the outline has been expanded, as shown in Figure 2, to illustrate where and how this unit fits into the course of study.

- Composition of food
- Food acceptance
- Science and food
  - Water and solutions
  - pH
  - Colloidal systems
  - Browning reactions
- Use of heat
- Microbiological aspects of food preparation
- Carbohydrates
- Fats
- Proteins
  - Structure
  - Classification
  - Physical characteristics
  - Chemical properties
  - Reactions

Figure 1. Topic outline for a college-level undergraduate course in food preparation.

Protein food systems
- Eggs
- Milk and cheese
- Meat
  - Physical properties
    - --composition (muscle, connective tissue, fat, bone)
    - --affected by (age, species, feed, exercise)
    - --significance of (grading, cuts)
  - Chemical properties
    - --composition (protein, fat, water, minerals, carbohydrate, vitamins)
    - --affected by (age, species, feed)
  - Reactions
    - --storage (ripening, refrigerating, freezing, drying)
    - --application of chemicals (curing, tenderizing, food ingredients)
    - --application of heat
  - Measurements of reactions and/or changes

Figure 2. Expanded outline of the protein section, particularly meat, of the topic outline.

Eleven subunits were developed to explain the principles and concepts of application of heat to red meats. Because the self-instructional unit is the first developed following the proposed outline, a twelfth subunit on the structure of proteins was incorporated to facilitate understanding of the others. Thus, subunits on the structure of proteins; effect of heat on protein structure, muscle proteins, connective tissue proteins, color pigment, fat, water, vitamins and minerals, bone; dry and moist heat cooking methods; effect of external and internal temperatures on meat quality; and effect of cooking time on meat quality were included.

Food and chemistry texts, as well as research journals and articles, were reviewed and information relevant to each section was obtained. Based upon a study of this material and the prepared outline, behavioral objectives for the unit were prepared.

Commercial producers of audio-visual and instructional materials were contacted to determine the availability of prepared materials for fulfilling the objectives of the unit. In specialized areas, such as heat application to red meats, suitable prepared instructional materials are unavailable.

Based upon analysis of the material to be presented and availability of physical facilities, tape recordings and 2 x 2 in. slides were selected as the most efficient and effective modes of instruction to achieve the specified behavioral objectives. Factual information pertaining to heat application to red meats was organized and the text for the tape recording written and sketches of the visual material prepared. The text and sketches of visuals were reviewed by a limited number of students to insure the clarity and correctness of the unit. The prepared unit follows.

SELF-INSTRUCTIONAL UNIT

EFFECTS OF HEAT ON RED MEATS

A self-instructional unit on the concepts and principles involved in the application of heat to red meats.

AN OVERVIEW

The purpose of this self-instructional unit is to present the concepts and principles involved in the application of heat to red meats. To better understand the effect of heat on meat, we will review the composition of meat and study the effect of heat on these individual meat components. Following this, we will consider meat as an integrated whole and study the effects of various cooking methods, times and temperatures on the quality of cooked meat.

Meat is composed of protein, fat, water and bone. Vitamins and minerals are also present in minute quantities. The protein portion is further divided into muscle protein, connective tissue and the color pigment.

Our study of the individual meat components will begin with a review of protein in general, considering both its structure and reactions to heat. Next, we will discuss individually the effect of heat on the three types of protein found in meat; the muscle protein, connective tissue and color pigment. Preceding each of these discussions, we will briefly review the structure of the component to facilitate our understanding of the reactions to heat.

In succeeding sections our study will concern the effect of heat on the remaining meat components; the fat, water, vitamins and minerals as well as bone. After our discussion of the individual meat components, we will review the steps involved in the various methods by which meat is cooked. Then we will conclude the unit with a discussion of the effect of various cooking temperatures, both external and internal; various cooking times as well as other factors on the quality of cooked meat.

The self-instructional unit on the effects of heat on red meats has been divided into the following subunits.

I. Structure of Proteins
II. Effect of Heat on Protein Structure
III. Effect of Heat on Muscle Proteins
IV. Effect of Heat on Connective Tissue
V. Effect of Heat on Color Pigment
VI. Effect of Heat on Fat
VII. Effect of Heat on Water
VIII. Effect of Heat on Vitamins and Minerals
IX. Effect of Heat on Bone
X. Dry and Moist Heat Cooking Methods
XI. Effect of External and Internal Temperature on Meat Quality
XII. Effect of Cooking Time on Meat Quality

Behavioral objectives, numbered to correspond with the subunits, follow. The objectives summarize the main points you should acquire from each subunit. Hence, the objectives may be useful to you in evaluating your study of each subunit.

Behavioral Objectives

I - 1 Draw the structural formula of an amino acid showing the amino group ($-NH_2$) on the carbon atom adjacent to the carboxyl group ($-COOH$).

I - 2 Describe the structure of a protein as a high molecular weight, organic compound composed of amino acids linked together by peptide bonds to form polypeptide chains which are maintained in a folded or coiled position by intramolecular bonding and/or van der Waals forces.

I - 3 Explain the amphoteric nature of proteins as a function of the number of acidic carboxyl groups in relation to the number of basic amino groups.

II - 1 Define protein denaturation as an alteration in the structure of a "native" protein characterized by unfolding of the polypeptide chains and/or dissociation of the protein into smaller units by breaking intramolecular bonds and/or van der Waals forces.

II - 2 Explain muscle protein denaturation as a progressive reaction with increasing degrees of doneness associated with increasing denaturation; however denaturation of most meat proteins is complete when the meat is heated to an internal temperature of 60 to 70°C (140 to 160°F).

III - 1 State that muscle fibers decrease in length as well as width as the muscle proteins are heat-denatured.

III - 2 Explain changes in the diameter of muscle fibers as a function of reduced water-holding capacity of heat-denatured protein while changes in fiber lengths are associated solely with protein denaturation.

IV - 1 Identify the two types of connective tissues in a raw meat sample as collagen which is a white, non-elastic fiber and elastin which is a yellow, elastic fiber.

IV - 2 Given a piece of meat containing large amounts of collagen and elastin, recommend cooking by moist heat because collagen is hydrolyzed to gelatin in the presence of heat and water while elastin may be slightly softened.

V - 1 Describe the principle color pigment of raw muscle as a heme protein called myoglobin which is purplish-red in color.

V - 2 Explain that myoglobin combines readily with oxygen in the air or within the muscle to form the pigment, oxymyoglobin which is bright red in color.

V - 3 State that heat renders myoglobin and oxymyoglobin susceptible to oxidation and that the oxidized form of these two pigments is metmyoglobin which is brownish-red in color.

V - 4 Describe a fourth pigment which develops with continued application of heat as hemichrome which is gray or tan to brown in color.

VI - 1 Given a piece of meat containing large amounts of surface and intramuscular fat, explain the effects of heat application in terms of increased cooking losses as fat cells deposited on the surface and within the muscle are melted and accumulate as drip.

VI - 2 Given pieces of meat with and without surface fat, explain that surface fat serves as a protective coating for meat during cooking and thus inhibits moisture loss which leads to decreased cooking times.

VII - 1 Explain that water may be chemically bonded to muscle proteins or held physically immobile within the protein structure. The immobile water is released as protein is heat denatured.

VII - 2 State that the water present in meat functions as a solvent for certain minerals and vitamins.

VII - 3 Describe two reactions of water from the surface of the meat as evaporation and accumulation as drip.

VIII - 1 Explain that minerals may be extruded during heat denaturation of meat proteins and these minerals may be retained on the surface of the meat or transferred to the drip.

VIII - 2 State that some of the B vitamins in meat may be destroyed by heat, but that factors such as shape and size of the meat cut; cooking time, temperature and media; degrees of doneness as well as pH of meat and cooking media may affect the heat resistance of the B vitamins.

VIII - 3 State that the heat stability of the B vitamins is niacin greater than riboflavin which is greater than thiamine.

IX - 1 Explain that the presence of bone does not affect cooking times of meat but bone may help retain the shape of a meat cut during cooking.

X - 1 Categorize the seven methods for cooking meat as either dry or moist heat methods.

X - 2 State that the recommended temperature for roasting meat is 300 to 350°F.

X - 3 State that in moist heat cooking, the temperature of the cooking liquid should be just below the boiling point of water.

XI - 1 Explain that in general, high internal temperature, high cooking temperature and/or long cooking time are factors responsible for high cooking losses in a meat cut.

XI - 2 State that cooking losses are indirectly related to the juiciness of cooked meat.

XI - 3 Given a cut of meat containing minimal amounts of connective tissue, recommend a dry heat cooking method.

XII - 1 State that total cooking time is only an approximate indicator of degree of doneness.

Instructions

1- Put on the earphones
2- Turn on the tape recorder
3- Turn on the slide projector. Each time you hear a "peep" sound on the tape, advance the projector to the next slide.

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slide 1

I. Structure of Proteins

Proteins are one class of organic compounds present in biological tissue. These compounds have high molecular weights and yield amino acids on hydrolysis.

slide 2

Amino acids have an amino or amine group, $-NH_2$, attached to a carbon atom which is adjacent to a carboxyl group, $-COOH$.

slide 3

R represents any of a variety of possible groups. For example, R could represent a methyl group, $-CH_3$, to form the amino acid, alanine. Or R could represent a mercapto group, $-CH_2SH$, to form the amino acid, cysteine.

Eighteen or nineteen different amino acids are commonly present in most proteins. Some proteins contain three or four more amino acids, while only a limited number of proteins contain more than 23 amino acids.

slide 4

The amino group has a positive charge and reacts as an acid while the carboxyl group has a negative charge and reacts as a base. Hence, proteins may react either as bases or acids and therefore, are called amphoteric. Any decrease in either the number of amino groups or the number of carboxyl groups on the protein molecule will result in a change in the pH of the protein. For example, as carboxyl groups disappear, the remaining amino groups lead to an increase in the pH.

slide 5

Amino acids react with one another by elimination of a molecule of water from the amino group of one amino acid and the carboxyl group of another to form a peptide bond, -CONH-. The reaction to form a peptide bond is shown within the dotted red lines on the slide.

slide 6

The peptide formed from two molecules of amino acids can then react in the same manner with other amino acids to form a longer chain. The high molecular weight of proteins indicate many molecules of amino acids have combined in a polypeptide chain.

slide 7

The shape of the polypeptide chain may be either 1) folded as a puckered sheet or 2) coiled in a helix. However, the over-all shape of the polypeptide chain is not as orderly as the terms "folded as a puckered sheet" or "coiled in a helix" would imply. As just stated, the polypeptide chain is formed from many amino acids and the amino acids may be different; hence, they would vary in size as well as shape. Therefore, the shape of the protein molecule may be somewhat irregular to accommodate these structural differences. The shape is maintained by intramolecular bonds as well as van der Waals forces between portions of the polypeptide chain.

slide 8
(after Meyer, 1965)

The bonds may be 1) salt links between free carboxyl and free amino groups, 2) sulfur-sulfur links between sulfur-containing amino acids, 3) additional peptide links between free carboxyl and free amino groups, and 4) hydrogen bonding. The first three groups are primary chemical bonds and are fairly strong, but hydrogen bonds are weak and at high temperatures are easily broken.

Due to the folded or coiled shape of the polypeptide chain, water may be held physically immobile within the structure. Van der Waals forces may also play a role in holding water within the protein structure.

slide 9

To summarize, protein molecules are chains of amino acids linked together by peptide bonds. These chains may be folded as a puckered sheet or coiled in a helix. Within the folded or coiled chains water may be entrapped. The shape of the protein molecule is maintained by intramolecular bonds and van der Waals forces. Due to the presence of both acidic carboxyl groups and basic amino groups, proteins may react either as acids or bases.

slide 10

II. Effect of Heat on Protein Structure

Now that we have reviewed the structure of proteins, let's see how they are affected by heat.

Proteins as they occur in the tissues are called "native" proteins. Heating brings about a disorganization or denaturation of the native protein molecule. This disorganization involves changes from the somewhat regular arrangement of the protein molecule to an irregular arrangement. The extent of disorganization differs with various proteins depending upon their heat susceptibility.

slide 11
(after Kauzmann, in Harrow _et_ _al_., 1962)

Denaturation is of two types; 1) unfolding of the polypeptide chains, and 2) a dissociation of the protein into smaller units which may or may not unfold. The type of denaturation which occurs depends on the nature of the protein itself. The first type of denaturation involves proteins with one continuous polypeptide chain. The second type of denaturation occurs with proteins composed of a series of subunits held together by intramolecular bonds.

Of the various intramolecular bonds, hydrogen bonds are the weakest, and hence, most easily broken. As these bonds break, the peptide chain unfolds, uncoils and/or dissociates. During these processes, certain groups, such as -SH and -S-S-, which may be "buried" within the folded or coiled structure of the native protein, are freed and made available for further reactions.

slide 12

Denaturation represents a series of related reactions. These reactions have been studied in relation to internal temperatures of heating meats during cooking (Hamm <u>et</u> <u>al</u>., 1960). Between 20 and 30°C (68 and 86°F) no denaturation is apparent in meat proteins. The rigidity which is characteristic of denatured proteins or cooked meats has not yet started.

slide 13

Between 30 and 40°C (86 and 104°F), the peptide chains begin to unfold and new cross linkages or bonds may be formed as the protein molecule is rearranged. Gradually, the firmness of the meat increases. At these temperatures, there are no observable changes in the pH of the meat which is approximately 5.5 when the meat is raw. However, some water entrapped within the coiled or folded protein molecule is freed. This water may be slowly evaporated from the surface of the meat or it may accumulate in the cooking pan or cooking media.

When the temperature of the meat rises to 40 to 50°C (104 to 122°F) the pH begins to increase. However, the cooked meat remains slightly acidic. The firmness of the piece of meat continues to increase.

slide 14

Between 50 and 55°C (122 and 131°F) new and stable cross-linkages are formed. These are mainly disulfide linkages; however, some ester bonds may be formed. Between these temperatures no change in the pH is noted.

The formation of new cross-linkages continues between the temperatures of 55 and 80°C (131 and 176°F). Also, a rise in the pH is once again noticed.

slide 15

Denaturation of the meat proteins appears to be completed at 60 to 70°C (140 to 158°F). However, firmness of the meat continues to increase as the internal temperature of the meat increases.

slide 16

After the meat proteins have reached a temperature of 80°C (176°F), formation of free hydrogen sulfide is evident. Increased amounts of H_2S are formed with increasing internal temperatures of the meat. The H_2S is partly responsible for the characteristic aroma associated with cooked meat.

slide 17

In summary, we have defined denaturation as an alteration in protein structure. The polypeptide chains of the protein molecules unfold and/or dissociate into smaller units. In the process, new crosslinks are formed.

Denaturation is a progressive reaction and the phenomena occurring at various temperatures were noted. For example, some protein denaturation occurs below a temperature of 60°C (140°F) and by the time a temperature of 60 to 70°C (140 to 158°F) has been reached, most of the meat proteins are denatured.

slide 18

III. Effect of Heat on Muscle Proteins

We have considered the changes which occur when proteins are denatured by heat. Now let's observe the changes which result in meat when muscle proteins are heat denatured. Let's begin by briefly reviewing the physical structure of meat.

slide 19

The muscle portion of meat is made up of fibers held together by a very thin network of connective tissue called the endomysium. The long slender fibers may vary in diameter, but in general, are about the dimension of a human hair and may extend the full length of the muscle or less. The fibers are grouped parallel to each other in bundles and each bundle is surrounded by a thin network of connective tissue referred to as the perimysium. To complete the muscle structure, many bundles are surrounded by yet another network of connective tissue called the epimysium. Bundles may vary in size depending on the activity of the muscle of which they are a part.

slide 20
(after Hostetler *et al*., 1968)

To study the effect of heat on individual fibers, the muscles have been separated into their component parts. Then, heat has been applied to the fibers (Hostetler *et al*., 1968).

Fiber diameter decreases as the temperature rises. However, these decreases in diameter are complete by the time the fibers have been heated to approximately 62 to 67°C (144 to 153°F) with the most rapid decreases occurring between the temperatures of 45 to 62°C (113 to 144°F).

slide 21
(after Hostetler *et al*., 1968)

Some decreases in diameter also occur, but to a lesser extent, when muscle fibers are held at constant temperatures for extended periods. These slight decreases occur regardless of what the constant temperature is.

Changes in the diameter of fibers are probably due to shrinkage as water is lost from the fiber. As proteins are denatured by heat, their ability to hold water, or their water-holding capacity, is reduced. That is, water which is held within the polypeptide chain is released as the chain unfolds or uncoils.

slide 22
(after Hostetler *et al*., 1968)

Muscle fibers also shorten when heat is applied. However, this occurs very slowly if at all up to temperatures of 55°C. Then, between 55 and 56°C (131 and 133°F) most of the muscle fibers shorten rapidly to about 80% of their original length. Increasing the temperature to 80°C (176°F) results in an additional 10% decrease in fiber length.

Decreases in the length of fibers don't appear to be associated with loss of moisture from the fiber. Instead, shortening appears to be associated with the actual denaturation processes of the muscle proteins.

slide 23

Rising temperatures of meat are associated with increased firmness of the muscle. However, there is evidence that when the muscle reaches a very high temperature, 90 to 95°C (194 to 203°F) or higher, muscle softening occurs. This is perhaps because high heat, especially over extended time periods, results in extensive gelatinization of the connective tissue which surrounds the muscle fibers. Consequently, the fibers fall apart.

slide 24

In summary, we may say that as heat is applied to muscle proteins and the proteins denature, muscle fibers decrease in both diameter and length. Diameter changes are attributed to loss of water as denaturation reduces the water-holding capacity of the proteins. Changes in fiber length are associated with the phenomena of protein denaturation and are not related to moisture losses.

slide 25

IV. Effect of Heat on Connective Tissue

We have discussed the effects of heat on the muscle proteins. Let's consider the effects of heat on the connective tissue proteins.

slide 26

Connective tissue, we know, is the general name for the combination, collagen and elastin. Collagen refers to the protein which forms the white fibrous network surrounding the fibers, bundles and muscles. Collagen is flexible; however, it does offer resistance to stretching.

Elastin is the protein forming the yellow elastic fiber. It is an important component of ligaments which perform various functions, such as connecting two bones or cartilages. This tissue is stretchable.

slide 27

Let's first consider the effect of heat on collagen. When heat is applied in the presence of water, collagen is hydrolyzed. Hydrolyzation refers to the chemical decomposition or splitting of a compound by using water. With hydrolyzation, collagen is converted to gelatin. The gelatin is in a viscous or liquid state when warm or hot; however, when cooled, gelatin becomes a solid.

As just stated, it is imperative that water be present for hydrolyzation to take place. When collagen is heated in air, slight softening may occur because small amounts of water are naturally contained within the collagen network structure. If heating in air is continued after the water has been utilized, the collagen becomes parchment-like. In addition to water inherent in the collagen network, the muscle proteins also contain some water which is available for hydrolysis of collagen.

slide 28

The conversion of collagen to gelatin is dependent upon water and heat. The rate of conversion is affected by the temperature reached. With increased temperatures, increased amounts of collagen are converted to gelatin. For example, little conversion occurs below temperatures of approximately 60°C (140°F). However, temperatures reached when collagen is autoclaved, result in complete hydrolysis.

In addition to heat and water, time is required for hydrolysis of collagen to gelatin. Research on the physical changes of beef connective tissue with heating showed that little hydrolyzation occurred with heating periods of less than four minutes at 65°C (149°F), but definite changes occurred when heating continued for 16 or 64 minutes (Winegarden _et al_., 1952).

slide 29
(after Winegarden _et al_., 1952)

Along with hydrolysis of collagen, changes occur in the physical appearance of the network of fibers. As happened with protein muscle fibers, collagen fibers decrease in length and diameter. These changes increase with increasing temperature and time (Winegarden _et al_., 1952). The shrinkage of the collagen fibers within a strip of connective tissue results in an increase in thickness of the connective tissue strip.

slide 30

Little definitive research or information exists pertaining to the effect of heat on elastin, the second general protein classification in connective tissue. It is known that elastin can soften similarly to collagen; however, this does not occur to the same extent.

Since elastin is affected less by heat, we can expect the greatest changes in meat tissues to be in those which contain the greatest amount of collagen and least in those containing the most elastin.

slide 31

To summarize, connective tissue, we noted, is composed of white fibers called collagen and yellow elastic fibers called elastin. When heat is applied to the collagen in the presence of water, hydrolyzation occurs and the collagen is converted to gelatin. Substantial conversion requires temperatures above 60°C (140°F) and extended heating periods. While elastin can soften in a manner similar to collagen, it does so to a considerably lesser extent.

slide 32

V. Effect of Heat on Color Pigment

Color pigments are another component of meat. The principle color pigment of muscle is a protein called myoglobin. In addition to myoglobin, traces of the blood pigment, hemoglobin, may also be present in meat. While the role of hemoglobin is to transport oxygen to the muscles, myoglobin holds the oxygen in the tissues so the oxygen is available as needed for muscle contraction.

slide 33

Myoglobin and hemoglobin are both heme proteins. That is, they are composed of hemin plus a simple protein. Hemin is an iron-containing compound responsible for the color of both of these pigment proteins. The hemin portion of myoglobin and hemoglobin is identical, however, hemoglobin contains four heme units while myoglobin contains only one. The protein portions of these pigments are different.

slide 34

Myoglobin is purplish-red in color. It combines readily with oxygen in the air or within the muscle to form the oxygenated pigment oxymyoglobin, which is bright red in color. These two pigments exist in equilibrium in living muscle tissue.

In dressed meat, which is exposed to oxygen in the air, oxymyoglobin is the predominate pigment. When heat is applied to muscle, it renders the myoglobin and oxymyoglobin pigments susceptible to oxidation. The oxidized form of myoglobin and oxymyoglobin is called metmyoglobin, a brownish-red pigment.

slide 35

In meat cooked to the rare stage, 54 to 66°C (131 to 149°F) the bright red color is attributable to a predominance of oxymyoglobin. As the meat is cooked to higher internal temperatures, the proportion of oxymyoglobin decreases.

The pigment formed which is responsible for the gray or tan to brown color of well-done meat is hemichrome. The progressive development of hemichrome from myoglobin and oxymyoglobin with the application of heat is evident in the samples of roast beef cooked to the rare, medium and well-done stage pictured in the slide.

slide 36

To summarize, the principle color pigment of meat is a heme protein called myoglobin. Myoglobin which is purplish-red in color combines readily with oxygen either in the air or in the muscle to form the bright red pigment oxymyoglobin. Heat renders both of these pigments susceptible to oxidation to form the brownish-red pigment, metmyoglobin. A fourth pigment which develops with continued application of heat is hemichrome which imparts a gray or tan to brown color to the meat.

slide 37

VI. Effect of Heat on Fat

Fat is another component of meat.

slide 38

Fat cells are found scattered throughout the connective tissue network and in deposits of varying sizes within the muscle tissue. Surface fat is also deposited by the animal during growth and many cuts of meat display this layer of surface fat. Fat cells of the fat deposits as well as surface fat are surrounded by a connective tissue network.

slide 39

When heat is applied to fat, it softens and as the temperature increases, the fat melts. During cooking, fat cells which are present on the surface of the meat accumulate as drip in the cooking pan or cooking liquid when the melting temperature of the fat is reached. Fat which is embedded within the muscle tissue also melts and after collagen has been hydrolyzed to gelatin a pathway for the escape of the melted fat is provided.

As indicated previously, fat cells are surrounded by a network of connective tissue. When subjected to heat, the connective tissue network shrinks thereby squeezing the fat cells. Thus liquid fat is forced from the surface fat and fat deposits to either accumulate as drip or disperse within the muscle.

slide 40

When fat is present on the surface of a cut of meat, it serves as a protective coating thereby inhibiting the escape of moisture from the portion of the muscle which is covered with the fat. This is reflected in the increased juiciness of the cooked meat.

slide 41
(after Funk *et al*., 1968)

A second effect of surface fat is to function as an insulator during cooking. Because heat and/or moisture cannot escape from the surface of the meat, the cut of meat which is surrounded by surface fat tends to cook in a shorter period of time (Funk *et al*., 1968).

slide 42

Summary: Fat cells, which we observed were deposited both within the muscle and on the surfaces of the muscles, are melted when heat is applied. This liquid fat may then accumulate as drip in the cooking utensil or disperse throughout the muscles following the pathways provided by hydrolyzed collagen. Fat on the surface of meat serves both as a protective coating inhibiting the escape of moisture and as an insulator to increase the speed with which meat cooks.

slide 43

VII. Effect of Heat on Water

Water constitutes a very large portion of muscle meats, about 70%. Part of the water is actually bound or bonded to the muscle proteins. This is termed "water of hydration".

The remaining water is held physically immobile within the protein structure. It is this immobile water which is most affected when heat is applied to a cut of meat.

slide 44

In the discussion of protein denaturation, we noted that the water-holding capacity of proteins is reduced during denaturation of the proteins. As the protein molecule is unfolded or uncoiled, the immobile water is released. This water can then be extruded from the muscle. Extrusion is aided by the shrinkage and contraction of the connective tissue network and by the hydrolyzation of collagen to gelatin which provides a pathway for escape of moisture.

As water escapes to the surface of the muscle, it may evaporate in the heated atmosphere surrounding the meat during cooking. Or, the water may accumulate as drip in the cooking pan or cooking liquid.

You will recall from your chemistry, liquids show some tendency to evaporate or change into a gas at all temperatures, but this tendency increases as the temperature rises. Thus, as the temperature of the meat or the atmosphere surrounding the meat increases, increased amounts of water are evaporated from the meat. This is reflected in increased cooking losses.

The amount of moisture evaporated from the meat increases with time, also. Thus, the longer a cut of meat is cooked, the greater is the amount of water which will be lost. This is reflected in decreased juiciness of the meat.

As noted previously, water may accumulate as drip in the cooking pan. This water may evaporate from the pan during the cooking process. However, if quantities of fat are present in the drip, the fat may form a protective coating over the surface of the water thereby preventing evaporation. The fat forms the protective coating because it has a lower specific gravity than the water.

Water present in the muscle tissues of meat functions as a solvent for certain minerals which are present as soluble salts, water-soluble vitamins and water-soluble proteins. When water is lost from the meat, these soluble components are also extruded.

slide 45

To summarize, we noted that approximately 70% of muscle is water. This water may be either bound to the muscle proteins or merely held physically immobile within the protein structure. It is the immobile water which is most affected by heat application because as denaturation progresses and the polypeptide chain uncoils or unfolds the immobile water is released. Water which reaches the surface of the meat may then evaporate or accumulate as drip. The quantity of water which is lost from meat is directly related to both the cooking temperature and cooking time. Because water is also a solvent for some minerals and vitamins of meat, these may be lost along with the departing water.

slide 46

VIII. Effect of Heat on Vitamins and Minerals

When we discuss the effect of heat on the components of meat, a primary consideration must be the effect of heat on the vitamin and mineral content.

slide 47

While lean pork is considered to be an outstanding source of thiamine, all lean meats contain some thiamine, as well as niacin and riboflavin. In addition, vitamin A is found in the liver of all animals, but not extensively in other parts of the carcass.

As we have indicated previously, red meats contain iron. In addition to the iron, meat contains enough phosphorus and copper to rate as a significant source of these minerals.

slide 48

About 10% of the total minerals which are present as soluble salts in the meat may be extruded during protein denaturation and/or moisture evaporation. The extruded minerals may be retained on the surface of the meat as moisture evaporates during dry heat cooking such as oven roasting. Or, the extruded minerals may transfer to the drip which accumulates in the pan or cooking liquid during cooking.

Mineral losses resulting from cooking are minimal under normal cooking procedures. If meat is cooked for prolonged periods in water, however, as much as 80% of the minerals may be lost into the cooking liquid. In such instances, the cooking liquid should be consumed to obtain maximum nutritive value.

slide 49
(after Farrer, 1955)

In contrast, some of the B vitamins (such as thiamine) which are found in meat are not as heat resistant as the minerals. In addition to heat, other factors which may influence the retention of thiamine in meat include the shape and size of the piece of meat; cooking times, temperatures and media; degree of doneness; and the pH of the meat and/or cooking media. Because of all of these influencing factors, it is difficult to make definite statements on thiamine retention in cooked meats. However, trends can be noted.

Roasting will usually lead to a loss of 40 to 60% while stewing losses may vary from approximately 50 to 75%. Braising will on the average, give a loss of 40 to 45%; however, losses may go as high as 75%. Frying losses ranging from 8 to 80% have been reported while broiling losses are generally 20 to 40% (Farrer, 1955).

slide 50
(after Tucker et al., 1946)

Unlike thiamine, riboflavin is fairly heat and air stable; however, the vitamin is photolabile (destroyed by light). In a test made on beef, approximately 100% total retention of riboflavin was found when the meat was braised, fried or broiled. However, some of this riboflavin was transferred from the meat to the drip. Drip contained 26, 2 and 5% when the meat was cooked by braising, frying and broiling, respectively (Tucker et al., 1946).

slide 51

Niacin is stable to heat and air. Losses during cooking of meat are insignificant.

Vitamin A is comparatively stable to heat. Because this fat soluble vitamin is found predominantly in the liver, which is low in fat, vitamin loss is negligible as only minute quantities of fat may accumulate as drip during cooking.

slide 52

IX. Effect of Heat on Bone

Another integral component of most cuts of meat is bone, and, unless the bone is removed, it can account for a large proportion of the mass of some cuts of ready-to-cook meat.

slide 53

Little definitive research has been conducted on the effects of heat on bone. Although the protein matter of bone, the ossein, can be converted to gelatin if it is freed from the mineral portion of the bone, the separation of these two components is very difficult and does not occur with ordinary cooking procedures. With prolonged cooking in moist heat, though, the cartilage masses in joints and the connective tissue sheath covering bone may be converted to gelatin. As a result, bones may separate at the joints and appear dull or rough on the surfaces.

During cooking, exposed marrow within bones may escape. When liquids are used in the cooking, they may be thickened slightly by the escaped bone marrow.

slide 54

Studies suggest that bone helps to retain the shape of a piece of meat during cooking. But, bone has no apparent effect on the losses from meat during cooking (Funk _et_ _al_., 1968).

Some researchers have studied the effect of bone on cooking times. Their studies have shown that bone would increase cooking times in meat when cooking times were calculated on a minutes per pound basis. However, when cooking times for bone-out and bone-in meat cuts were compared on the basis of the amount of muscle meat, no appreciable differences were found (Paul, 1950).

slide 55

X. Dry and Moist Heat Cooking Methods

We have discussed the changes, both physical and chemical, which occur when heat is applied to the individual components of meat; the proteins, fats, moisture, vitamins, minerals and bone. In reality, of course, we are dealing with all of these individual components at once when we cook a cut of meat.

Let's now consider the effect of various cooking methods, times, temperatures and other factors upon the tenderness, flavor, juiciness and overall palatability of meat. We will use beef as our example, but the principles are applicable to other meats.

slide 56

Basically, meat is cooked either by dry heat or by moist heat. Dry heat cooking includes roasting, broiling, pan broiling, and frying (both deep fat and shallow panfrying). Moist heat cooking entails cooking in liquid as is done in braising or stewing. Let's review the steps involved in each cooking method as recommended by the National Live Stock and Meat Board.

slide 57

The steps for the dry heat method of roasting are as follows.

1. Season with salt, if desired. Because salt only penetrates a fourth to a half inch, roasts may be seasoned either before, during or after cooking.

2. Place meat, fat side up, on rack in open shallow roasting pan. The roast is held out of the drippings by the rack. The fat on top bastes the meat as it melts and prevents moisture loss.

slide 58

3. Insert a meat thermometer so the bulb is in the center of the largest muscle. The bulb should not touch bone or rest in fat.

4. Do not add water or cover the meat. This would change the cooking to a moist heat method. Covering prevents the excape of evaporating moisture, thereby creating a moist atmosphere around the roast.

slide 59

5. Roast in a slow oven--300 to 350°F. Small roasts (5 pounds or less) may be cooked at 350°F, larger roasts (6 or more pounds) are better if cooked at 300°F.

slide 60

6. Roast to desired degree of doneness according to the meat thermometer.

140°F (60°C) for rare
160°F (71°C) for medium
170°F (77°C) for well done

Because roasts are more difficult to slice immediately after their removal from the oven, they should be allowed to stand before carving. During this period, the internal temperature of the meat continues to rise. Therefore, to prevent overcooking, the roasts should be removed from the oven when the thermometer registers 5 to 10°F lower than the desired doneness.

slide 61

Broiling is another procedure for cooking meat with dry heat. Broiling may be done in the oven or in a frying pan. The steps for oven broiling are given followed by the procedure for pan-broiling.

1. Set the oven regulator for broiling. Preheat broiler as indicated in the instructions for the oven used.

2. Place the meat on the rack of the broiler pan and adjust pan until meat is desired distance from the heat.

Two to three inches is best for cuts which are 3/4 to 1 inch thick. Three to five inches is better for cuts 1 to 2 inches thick.

slide 62

3. Broil until top side is brown. The meat should be approximately, or slightly more than, half done at this point.

4. Season the top side, if desired. Broiled meats are seasoned after browning since salt tends to bring moisture to the cut surface and delay browning.

slide 63

5. Turn and brown the other side. Then season the second side, if desired.

slide 64

Meat cuts which are less than one inch thick may be panbroiled according to the following procedure.

1. Place meat in heavy frying pan or on a griddle. The pan or griddle need not be preheated.

2. Do not add fat or water or cover. Most meat cuts have enough fat to prevent their sticking; however, the frying pan may be lightly brushed with fat when very lean cuts are panbroiled.

slide 65

3. Cook slowly, turning occasionally. Slow cooking insures gradual browning which is better than browning the meat quickly at the beginning or searing. Searing does not hold in meat juices. Turning more than once is essential for even cooking since the meat is in direct contact with the hot metal of the pan or griddle.

slide 66

4. Pour off or remove the fat as it accumulates. Failure to remove the fat results in frying the meat rather than panbroiling.

5. Do not overcook. Season if desired. Pan or griddle broiling requires about half the time of broiling in the oven. To test for doneness, cut a small slit near the bone and observe the color of the interior meat.

slide 67

Another method for dry heat cooking of meat involves the use of fat. Fat may be used in small amounts as in pan frying or in large amounts for deep-fat frying. Steps for panfrying and deep-fat frying follow.

Panfrying:

1. A small amount of fat may be added before, or allowed to accumulate during frying. Some cuts will fry in the fat that comes from the meat. Meats which are low in fat or have

been coated with flour or breading require additional fat to cover the surface of the frying pan and prevent sticking.

2. Season if desired. Seasonings may be added to the coating ingredients.

3. Do not cover the meat. Covering destroys crispness and changes the cooking method to moist heat. As in roasting, covering prevents the escape of moisture.

slide 68

4. Fry at moderate temperature, turning occasionally, until brown on both sides and done. Occasional turning insures even cooking. Do not allow the fat to smoke because smoke indicates a chemical breakdown in the composition of the fat and breakdown products affect the flavor of the cooked meat.

slide 69

Deep-fat frying:

1. Use a deep kettle and a wire frying basket. Use enough fat to completely cover the meat or a fat to food ratio of approximately 8 to 1.

2. Heat fat slowly to frying temperature. Temperatures between 300 and 360^{o}F (149 and 182^{o}C) are best depending upon the size of the pieces and whether the meat is precooked or raw. A frying thermometer is essential to maintain a constant fat temperature. Adjustments may have to be made

as food is added since this can cause the temperature of the fat to drop. As with panfrying, do not allow fat to smoke. Decomposition of frying fat will adversely affect the quality of the cooked product.

slide 70

3. Place meat in frying basket. Cook no more than will cover the bottom of the basket. Lower the basket into the hot fat gradually.

4. Brown meat and cook it through. No turning is necessary because both sides of the meat are cooked at once. For this reason, cooking time is less than in panfrying.

slide 71

5. When done, drain fat from meat into kettle and remove meat from basket.

slide 72

Meats may be cooked by moist heat methods such as braising or stewing. The steps in these procedures follow.

Braising:

1. Brown meat slowly on all sides in heavy utensil. Pour off drippings after browning. Browning develops the flavor and color. A brown which develops slowly stays on the meat better than a quick brown at a high temperature. Unless sufficient fat is present in the cut of meat, fat must be added to prevent sticking during browning.

2. Season, if desired. Seasoning may be added with the coating if one is used.

slide 73

3. Add a small amount of liquid. With tender cuts of meat, the addition of liquid is unnecessary.

slide 74

4. Cover tightly. A tight fitting lid holds in the steam.

5. Cook at low temperature until tender. Simmer, do not boil, either on top of the stove or in a slow oven (300 to 325°F).

slide 75

6. A sauce or gravy may be made from the liquid in the pan, if desired.

slide 76

Cooking in liquid:

1. Brown the meat on all sides, if desired. This develops flavor and color. If the meat is coated or is very lean, fat must be added.

2. Cover the meat with water or stock. The liquid may be either hot or cold. By covering the meat with liquid uniform cooking is insured without turning the pieces.

3. Season, if desired.

slide 77

4. Cover the pan with a tight fitting lid and simmer until tender.

5. If meat is to be served cold, let it cool and chill in the stock in which it was cooked. This increases flavor and juiciness and prevents excess shrinkage.

6. If vegetables are to be cooked in the same liquid, add them just long enough before serving to cook them.

7. A sauce or gravy may be made from the liquid in the pan, if desired.

slide 78

What determines whether we cook meat by a dry or moist heat method? In general, the tenderness of the cut is the determining factor. Tender cuts of meat are usually best when cooked by dry heat while less tender cuts are best cooked with moist heat.

Which are the tender and less tender cuts of meat? To some extent, tenderness may be influenced by exercise. Muscles such as those found in the legs and neck of the animal are exercised most; hence, they tend to be less tender. Muscles found in the plate and flank areas are used for abdominal support and therefore, cuts of meat from these areas also tend to be less tender. Muscles found along the back bone of the animal receive little exercise and consequently, cuts of meat from these muscles are tender.

slide 79

XI. Effect of External and Internal Temperature on Meat Quality

Temperature is a very important factor in meat cookery. We have discussed the effects of heat on the protein, fat and water components of meat. Hence, you know that muscle and connective tissue fibers decrease in size due to denaturation of the protein and moisture evaporation. Surface fat and fat deposits within the muscle tissues are melted when heat is applied. As a result of these phenomena, cuts of meat shrink or decrease in size during cooking.

slide 80

The losses resulting from the application of heat to the meat are spoken of as cooking losses. Fat, water, vitamins and other substances which accumulate in the pan during cooking are referred to as drip losses, while water and other substances lost through evaporation are known as volatile losses. Cooking losses are important because they affect the appearance and palatability of the meat as well as the amount of meat there is to serve.

Temperature is related to cooking losses in two ways. First, the external temperature at which meat is cooked affects cooking losses. And second, the internal temperature or the degree of doneness of the meat will affect cooking losses. Let's examine these two factors in more detail.

slide 81
(after Lowe, 1955)

What is the optimum external cooking temperature? This can be defined as the temperature which will produce the most palatable product with minimum cooking losses. This temperature varies for different methods of cooking as well as for different cuts of meat.

Generally, the lower the temperature at which meat is cooked, the lower the cooking losses. However, if the cooking time is exceptionally long at the lower temperature, cooking losses may be high due to the extended period during which moisture may escape. In addition, roasts which are cooked at low temperatures to the well done stage may be dry.

Temperatures ranging from 300 to 350°F are recommended for roasting beef, lamb and veal. However, a temperature of 350°F is recommended for pork to maximize the flavor of the cooked meat. Higher external temperatures are used for broiling and pan frying.

slide 82

When moist heat cooking methods are used, the liquid surrounding the meat should remain just below the boiling point of water. If the liquid is allowed to boil, the meat will shrink excessively during cooking. The palatability characteristics of flavor, juiciness and tenderness will also be inferior to the same characteristics of meat cooked at a simmering temperature.

slide 83
(after Lowe, 1955)

The internal temperature or degree of doneness to which meat is cooked influences shrinkage as much or more than does the external cooking temperature. In general, as the degree of doneness is increased, cooking losses are increased. This results because evaporation and drip losses occur continuously while meat is cooking, therefore the longer cooking periods associated with higher internal temperatures result in greater cooking losses. Cooking losses in turn are indirectly related to the juiciness of the meat. Therefore, rare-done meat will be more juicy than medium-done meat and medium-done meat will be more juicy than well-done meat.

Beef or lamb may be cooked rare, 140°F (60°C); medium, 160°F (71°C) and well-done, 170°F (77°C). Pork should always be cooked well-done, 170°F (77°C) for rib and loin roasts and 185°F (85°C) for other cuts (Carlin *et al*., 1965). Veal and poultry are usually cooked well done.

The most outstanding characteristic of rare meat is its color. Nearly all of the interior may be a bright red, or the gray color which is characteristic of well-done roast beef may extend to varying depths so that only a small spot in the center is red. The color of medium-done beef is more pink or rose verging into the grayish cast of well-done meat. When beef is cooked to the well-done stage the color is uniform gray throughout.

The effect of heat on the tenderness of meat is dependent on its composition. If large quantities of connective tissue are present, moisture, heat and time are required to hydrolyze the collagen which will subsequently result in tender meat.

We noted in our discussion of muscle fibers that increased heat causes the fibers to become firmer. Therefore with very lean cuts, the effect of heat on the meat fibers may result in a toughening of the cut.

slide 84

In summary, when we speak of temperature and its effect on meat, we must specify whether we mean external or internal temperature. However, both are directly related to cooking losses. We noted that in general, the lower the external cooking temperature, the lower the cooking losses. External temperatures of 300 to 350°F are recommended for roasting with higher temperatures suggested for broiling or panfrying. When moist heat cooking methods are being utilized, the cooking liquid should remain just below the boiling point of water. When meats are cooked to high internal temperatures, longer cooking periods are employed which allow increased time for moisture to evaporate. Any losses of moisture whether attributed to high external or high internal temperatures will result in decreased meat juiciness. Any effects of either the external or internal temperature will be modified by the meat's composition, that is the relation of lean to connective tissue. With very lean meat, excessive temperatures may result in a toughening of the muscle.

slide 85

XII. Effect of Cooking Time on Meat Quality

Timing is an important consideration in cooking meat. While it is often used as a guide to indicate doneness it must be emphasized that it is only a guide or approximation, for total cooking time is dependent upon many factors. Cooking temperature, method, size and shape of the meat cut, amount of aging, degree of doneness desired, initial temperature of the meat as well as its composition all influence the total cooking time.

slide 86

Any change in the external temperature will change the time required to cook a piece of meat to a desired degree of doneness. Lower temperatures require longer times than higher temperatures.

The cooking method affects cooking time. Meat reaches a specific internal temperature quickest in fat and slowest in air. In water, the cooking time to a specific external temperature is intermediate. Because escaping fluids are converted to steam in braising procedures, cooking time is shortened when meat is covered.

slide 87

While larger cuts of meat require longer total cooking times, they usually require fewer minutes per pound. The weight of a cut of meat is not the sole determinant of cooking time. A bulky cut of meat requires longer cooking than a flat thin one of the same weight.

Cuts of meat from aged beef also require slightly less time to reach the desired degree of doneness than those which are not aged. This is attributable to faster heat penetration of aged meat.

We have already mentioned the internal temperatures which correspond to the various degrees of doneness. As we noted, the higher the internal temperature the longer the cooking time.

The initial temperature of meat affects cooking time. When meat is still frozen, part of the heat must be used to melt the ice before cooking can begin. While meat may be cooked from either the frozen or defrosted state, frozen roasts will require approximately a third to a half again as long. The additional time required for cooking either steaks or chops is dependent upon their thickness and surface area. When broiling, frozen meats should be placed further from the broiler to insure that the interior is cooked to the desired degree of doneness before the exterior is overly browned. A hot pan should be used to pan broil frozen chops so the meat can brown before surface defrosting occurs which would retard browning. After browning the heat may be reduced.

In limited studies on the effect of fat content on cooking time, it is thought that exterior fat speeds the rate of heat penetration while interior fat may retard it (Thille *et al*., 1932).

slide 88

To summarize our discussion of cooking time, we must reemphasize that while total cooking time may be used as a guide to indicate doneness it is only an approximate indication. Many factors were mentioned as influencing the total cooking time; cooking temperature, cooking method, size and shape of meat cut, degree of doneness desired, initial temperature of the meat and composition.

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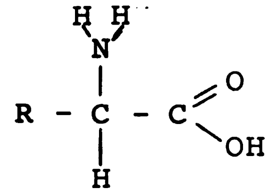
APPENDIX A

Sketches of Proposed Slide Visuals for Teaching the Effects of Heat on Red Meats

I. STRUCTURE OF PROTEINS

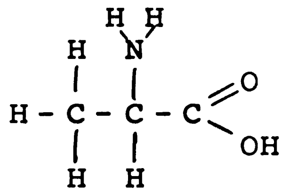
1



Amino Acid

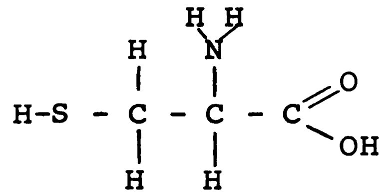
2

$R = CH_3$ (methyl)



alanine

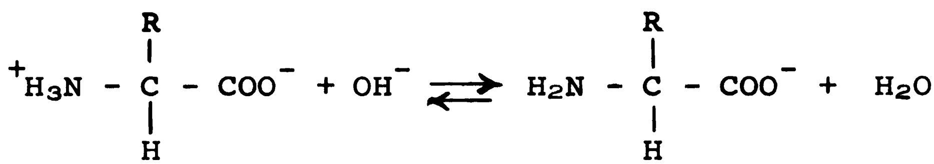
$R = CH_2SH$ (mercapto)



cysteine

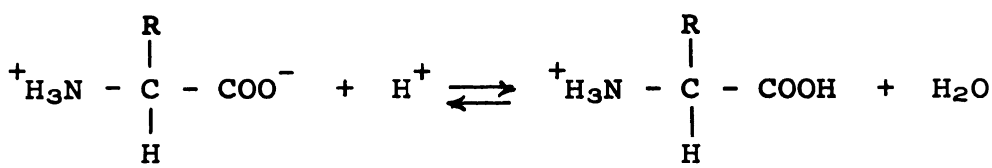
3

acting as an acid:



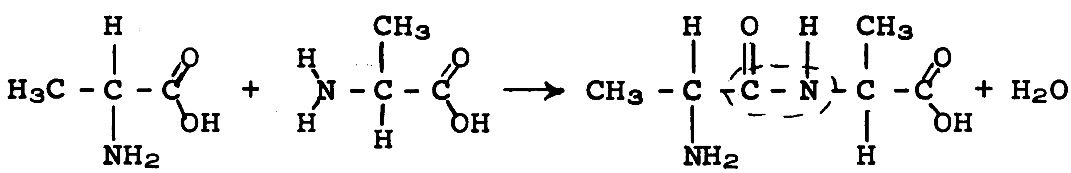
acid base

acting as a base:



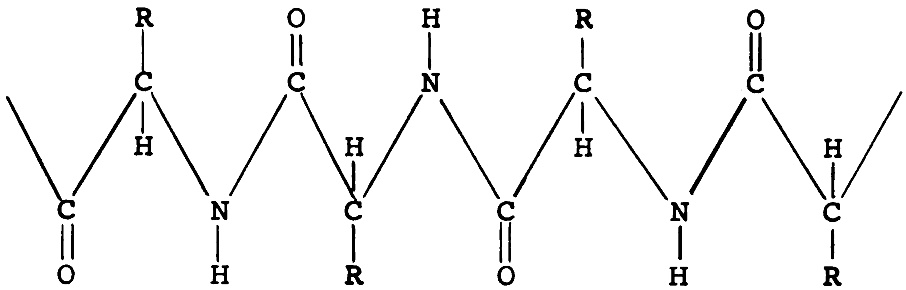
base acid

4



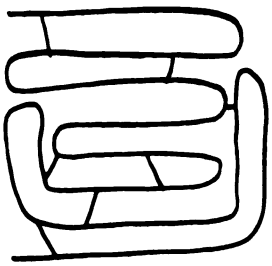
amino acid amino acid peptide bond

5

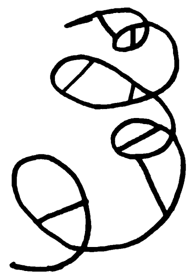


amino acid chain = protein

6

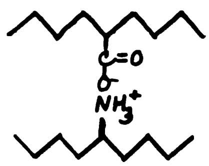


or

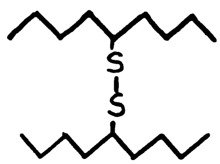


folded coiled

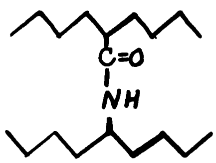
7



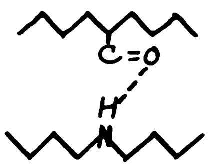
1) salt link



2) sulfur-sulfur link



3) peptide link



4) hydrogen bond

8

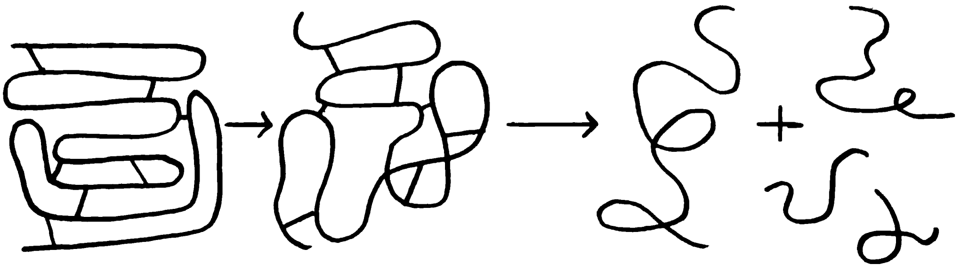
SUMMARY OF PROTEIN STRUCTURE

1) Are chains of amino acids linked by peptide bonds.
2) Chains may be folded or coiled.
3) Water may be entrapped within protein structure.
4) Shape maintained by intramolecular bonds and van der Waals forces.
5) Are amphoteric (may react as acids or bases).

9

II. EFFECT OF HEAT ON PROTEIN STRUCTURE

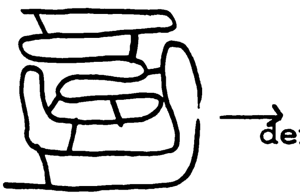
10



folded unfolding dissociated

DENATURATION OF "NATIVE" PROTEIN MOLECULE

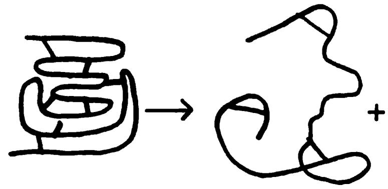
11



no denaturation

$20 - 30^{\circ}C$
$(68 - 86^{\circ}F)$

12

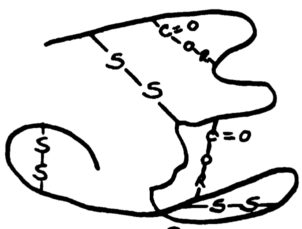


HOH ↑

HOH ↓

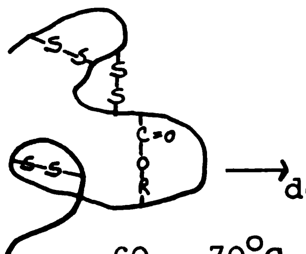
$30 - 40^{\circ}C$
$(86 - 104^{\circ}F)$

13



$50 - 55^{\circ}C$
$(122-131^{\circ}F)$

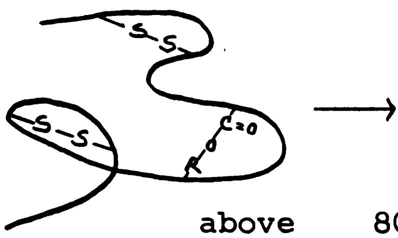
14



complete denaturation

$60 - 70^{\circ}C$
$(140-158^{\circ}F)$

15



H_2S

above $80^{\circ}C$
$(176^{\circ}F)$

16

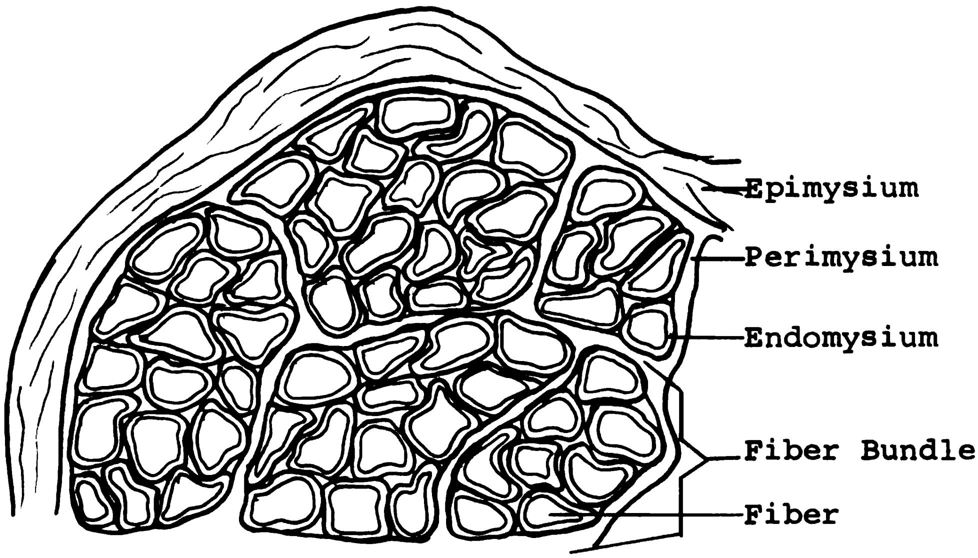
SUMMARY OF EFFECT OF HEAT ON PROTEIN STRUCTURE

1) Proteins denature (polypeptide chains unfold and/or dissociate).
2) Denaturation is a progressive reaction.
3) Denaturation predominantly complete at $60-70^{\circ}C$.

17

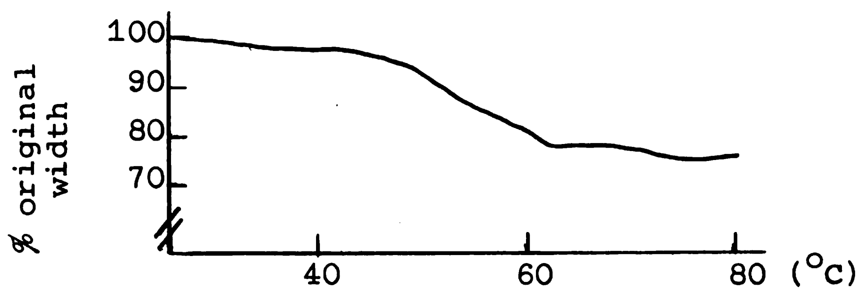
III. EFFECT OF HEAT ON MUSCLE PROTEINS

18



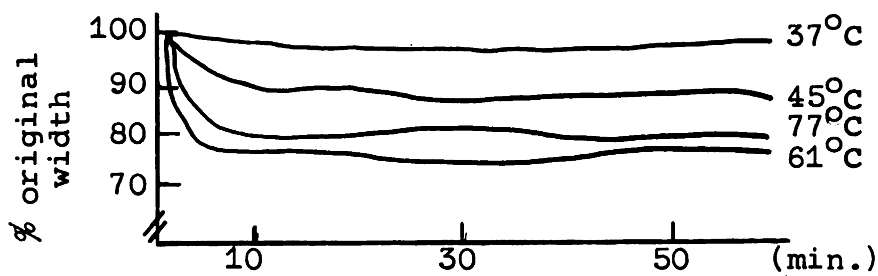
Muscle cross section.

19



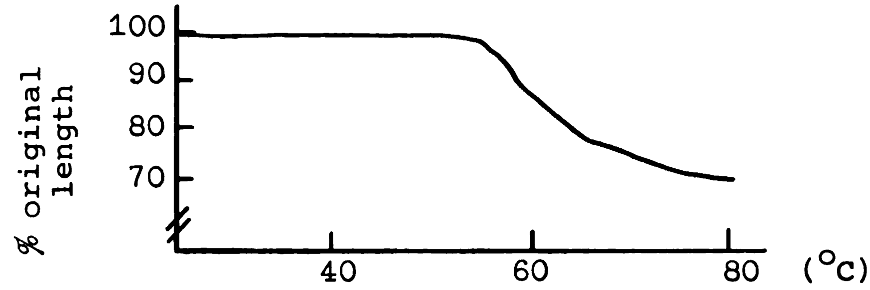
Fiber width decrease with increased temperature.

20



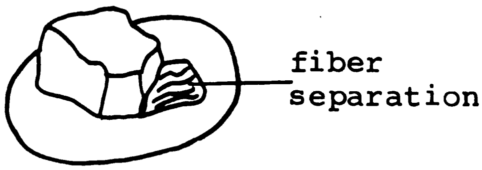
Fiber width decrease with time.

21



Fiber length decrease with increased temperature.

22



Picture of meat cooked to 90-95°C (194-203°F).

23

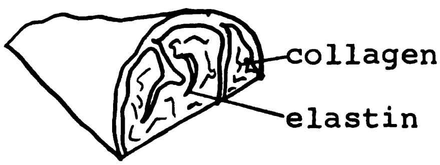
IV. EFFECT OF HEAT ON CONNECTIVE TISSUE

25

SUMMARY OF EFFECT OF HEAT ON MUSCLE PROTEINS

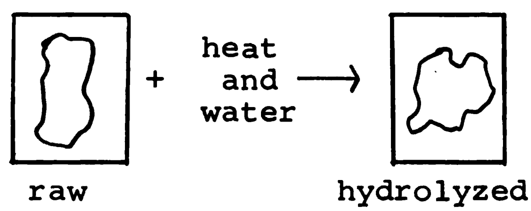
1) Muscle fibers decrease in diameter and length with increasing temperature.
2) Decrease in diameter related to loss of water.
3) Decrease in length related to protein denaturation.

24



Picture of heel of round of beef (raw).

26



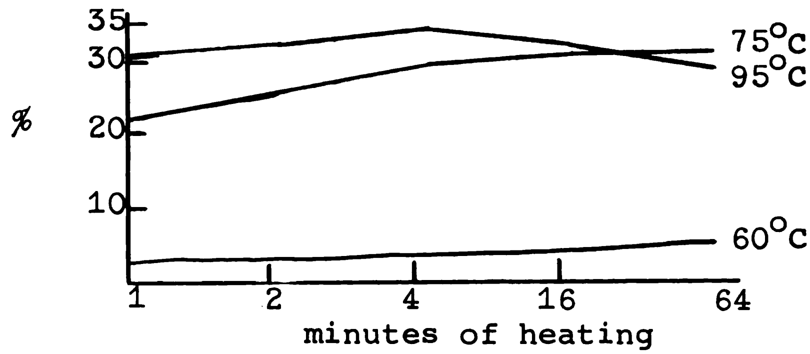
Picture of collagen before and after heating.

27

Collagen ⟶ Gelatin

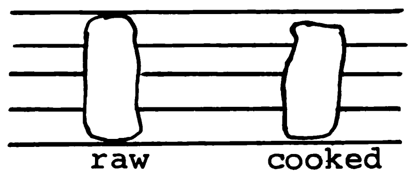
Conversion:
1) increases with increasing temperature
2) increases with increasing time

28



29

Percentage decrease in length of connective tissue strips.



Picture of elastin before and after heating.

30

V. EFFECT OF HEAT ON COLOR PIGMENT

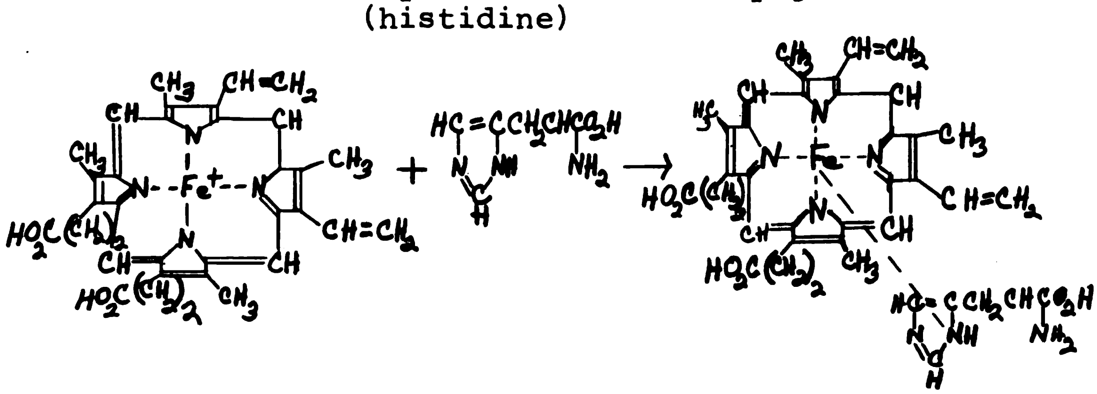
32

SUMMARY OF EFFECT OF HEAT ON CONNECTIVE TISSUE

1) Collagen = non-elastic white fibers.
2) Elastin = elastic yellow fibers.
3) Collagen + heat and water = hydrolyzation to gelatin.
4) Elastin + heat and water = only slight softening.

31

Hemin + Simple Protein (histidine) ⟶ Myoglobin

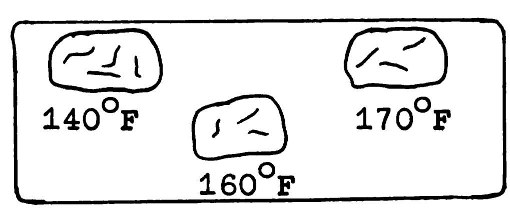


33

myoglobin ⇄ oxymyoglobin
(purplish-red) (bright red)

heat
↓
metmyoglobin
(brownish-red)

34



Pictures of cooked beef slices.

35

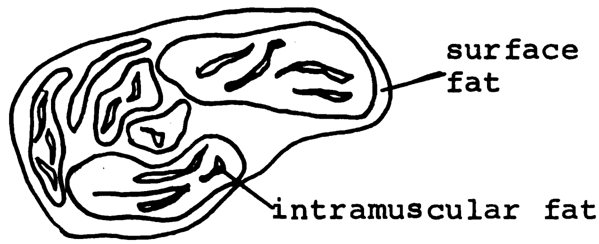
SUMMARY OF EFFECT OF HEAT ON COLOR PIGMENT

1) Myoglobin is principle color pigment of meat.
2) Myoglobin (purplish-red) + $O_2 \longrightarrow$ Oxymyoglobin(bright red).
3) Myoglobin or Oxymyoglobin + heat + $O_2 \longrightarrow$ metmyoglobin (brownish-red) $\downarrow$ hemichrome (gray, tan, brown)

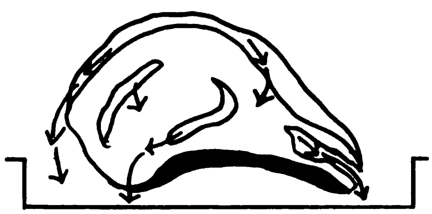
36

VI. EFFECT OF HEAT ON FAT

37

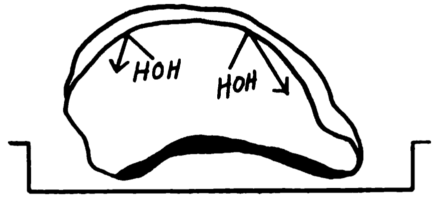


Location of fat within meat. 38



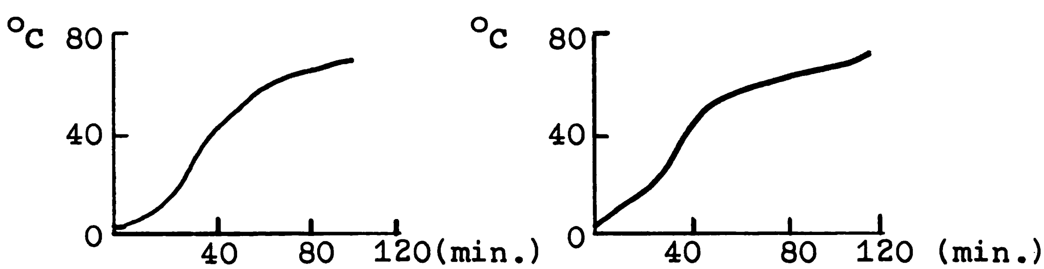
Relocation of melted fat.

39



Moisture retention.

40



Rates of temperature rise in fat-wrapped and plain ground beef cylinders. 41

SUMMARY OF EFFECT OF HEAT ON FAT

1) Fat is deposited within muscle and on surfaces.
2) Melted fat may accumulate as drip or disperse throughout muscle.
3) Surface fat inhibits moisture escape and acts as an insulator to speed cooking.

42

VII. EFFECT OF HEAT ON WATER

43

PROTEIN

unfolds
or
uncoils

immobile water released into muscle

connective tissue contracts and/or hydrolyzed collagen provides pathway for escape

water extruded from muscle

evaporation and drip

(increase with temperature)

44

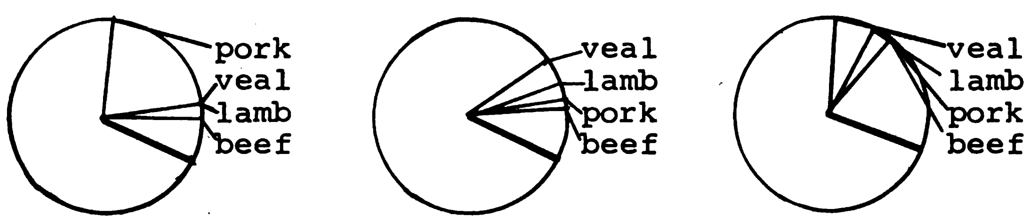
SUMMARY OF EFFECT OF HEAT ON WATER

1) Immobile water released with protein denaturation.
2) Released water may evaporate or accumulate as drip.
3) Quantity of water lost directly related to cooking time and temperature.
4) Water is solvent for minerals and vitamins.

45

VIII. EFFECT OF HEAT ON VITAMINS AND MINERALS

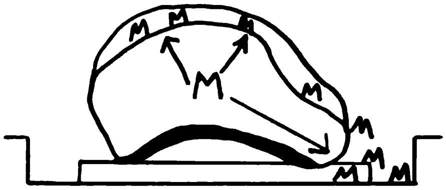
46



Thiamine Riboflavin Niacin

Percent of recommended daily dietary allowance of vitamin B supplied by 100 g raw beef, veal, pork and lamb (25 yr old, 154 lb man).

47

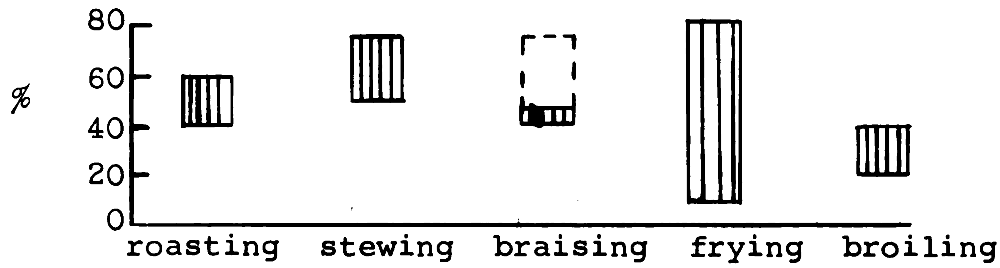


Effect of Cooking on Minerals
48

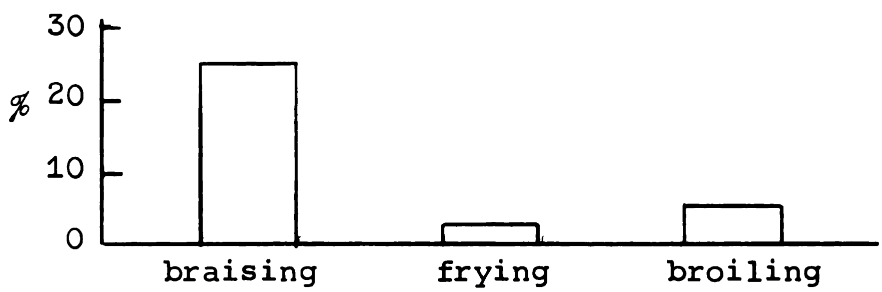
Niacin--stable to heat and air

Vitamin A--stable to heat and insoluble in water

51



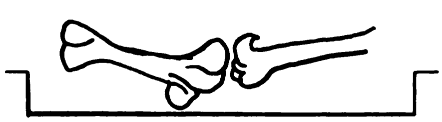
Effect of cooking method on percentage thiamine lost.
Shaded areas = range of losses
49



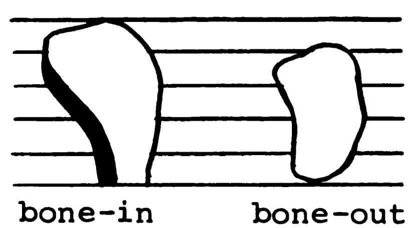
Percentage transference of riboflavin to drip, effect of various cooking methods.
50

IX. EFFECT OF HEAT ON BONE

52



Picture of pressure cooked beef joint.
53



Adjacent beef rib steaks cooked bone-in and bone-out.
54

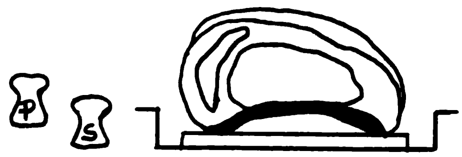
X. DRY AND MOIST HEAT COOKING METHODS

55

COOKING METHODS

Dry Heat	Moist Heat
1) roasting	1) braising
2) broiling	2) stewing
3) pan broiling	
4) frying	

56



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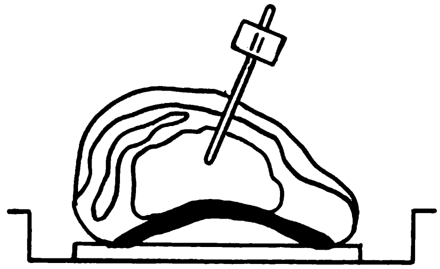

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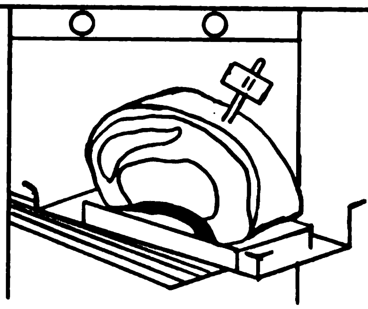

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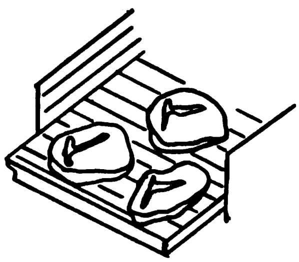
Desired Doneness	Internal Temperature
rare	140°F (60°C)
medium	160°F (71°C)
well-done	170°F (77°C)

60



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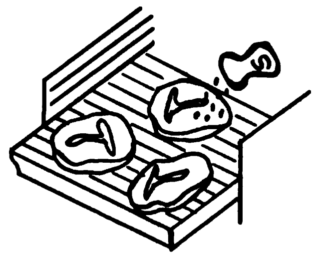

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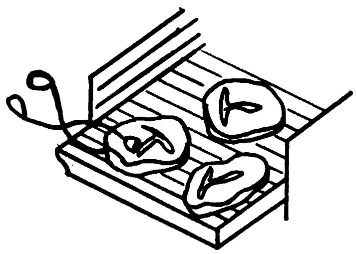

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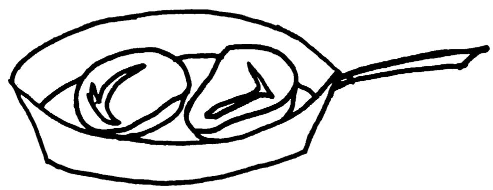

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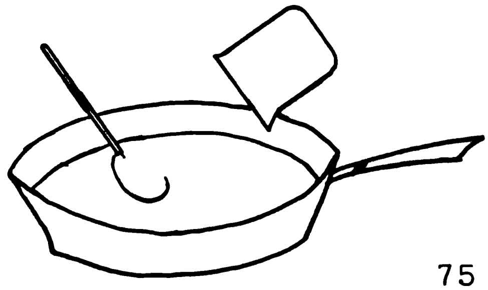

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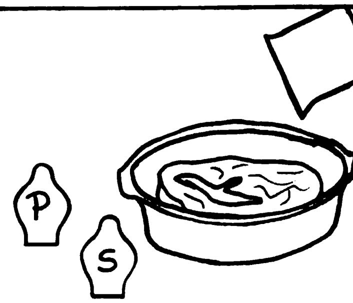

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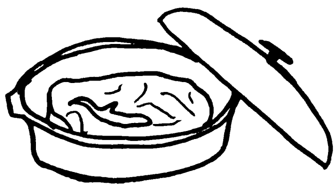

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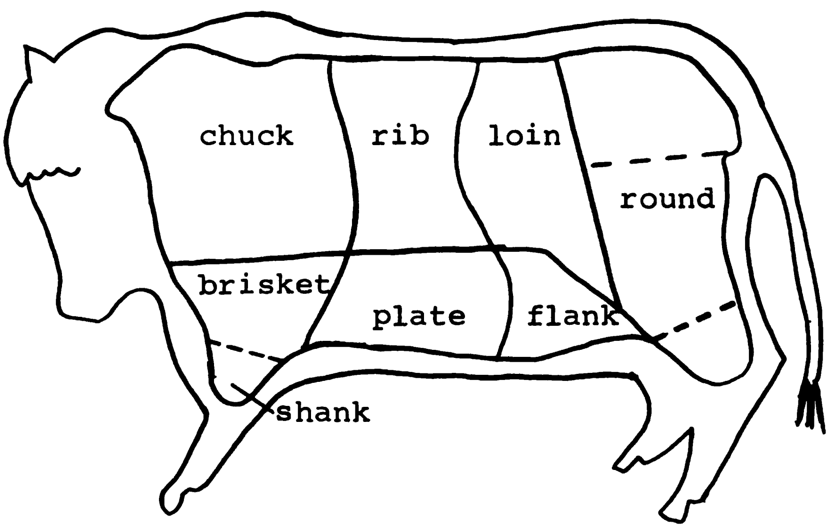
XI. EFFECT OF EXTERNAL AND INTERNAL TEMPERATURE ON MEAT QUALITY

79



78

COOKING LOSSES

<u>Drip</u>

1) fat
2) water
3) vitamins
4) minerals
5) other substances

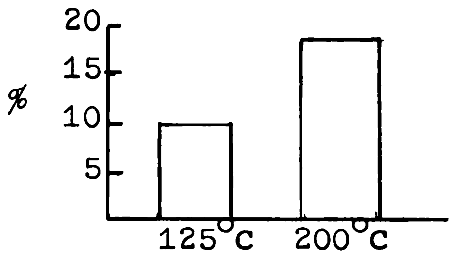
<u>Evaporation</u>

1) water

<u>Affect</u>

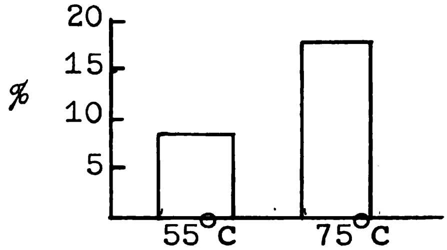
1) appearance
2) palatability
3) quantity

80



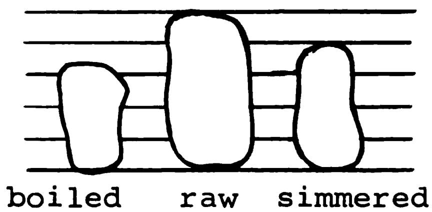
Effect of external temperature on percentage cooking loss for beef rib roasts.

81



Effect of internal temperature on percentage cooking loss for beef rib roasts.

83



Picture of raw, boiled and simmered beef samples.

82

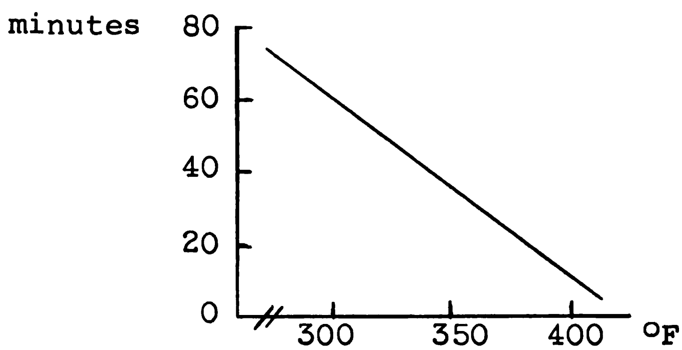
XII. EFFECT OF COOKING TIME ON MEAT QUALITY

85

SUMMARY OF EFFECT OF EXTERNAL AND INTERNAL TEMPERATURE ON MEAT QUALITY

1) Low temperatures = minimum cooking losses and greater juiciness.
2) 300 - 350°F is recommended for roasting.
3) Cooking liquid should remain below boiling point.
4) Effects of temperature modified by meat's composition.

84



Effect of external temperature on time required to cook beef to a constant end point temperature.

86

ADDITIONAL FACTORS AFFECTING COOKING TIME

1) Size--bulky cuts require longer cooking than flat, thin cuts of equal weight.
2) Aging--aged beef requires shorter cooking time.
3) Temperature
   - --higher internal end temperature = longer cooking.
   - --low initial temperature = longer cooking.

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SUMMARY OF EFFECT OF COOKING TIME ON MEAT QUALITY

Cooking time affected by:

1) cooking temperature
2) cooking method
3) size and shape of meat cut
4) degree of doneness
5) internal temperature
6) composition

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PROPOSAL FOR EVALUATION

A self-instructional unit should be evaluated in two contexts (Allender, 1967 and Deterline, 1967). First, the evaluation should ask if the unit facilitates attainment of its prescribed objectives and secondly, how it compares with traditional teaching methods in terms of effectiveness and efficiency.

This self-instructional unit was developed as an integral part of a potential food preparation course as outlined in Figure 1. This proposed outline attempts to organize food preparation principles according to the basic food components (carbohydrates, fat and protein), incorporating the various food products where needed to illustrate principles. Traditionally, food preparation courses have been organized according to food products. Because of this difference in orientation, no attempt was made to propose an evaluation of this unit against presently used teaching methods. A proposed method of evaluation of behavioral objective attainment, however, will be discussed.

Behavioral objectives were developed at the first three levels of the taxonomy of educational objectives; knowledge, comprehension and application (Bloom, 1956). Primarily the objectives are at the knowledge and comprehension levels because understanding of the principles of heat application is deemed most important at this level of study. In addition, some ability to apply these principles in simulated food preparation situations is necessary for complete understanding of the principles; therefore, objectives at the application level were developed.

To assess achievement of the behavioral objectives, a pretest and a post test were developed (Appendix B) to evaluate each of the behavioral objectives. The purpose of administering a pretest prior to studying the unit is twofold as noted by Mager (1967); 1) obtain a basis for determining which behavioral objectives were or were not achieved through study of the self-instructional material and 2) determine which behavioral objectives could be successfully achieved prior to use of the teaching unit.

Following the suggestion of Short _et al_. (1969), a multiple-choice design was employed for all pretest questions to provide a quick, efficient tool for behavioral objective assessment. Short _et al_. (1969) selected this design because they believed it permitted greatest flexibility in measuring the material and also provided greatest test reliability by reducing the element of chance in responding.

The post test is composed of fill-in-the-blank, short answer, matching as well as true and false questions. In a few instances one question evaluates more than one objective.

No more than one question for each behavioral objective was developed on both the pre- and post tests to facilitate comparison between the two tests. The tests were reviewed by a small sample of students in an attempt to insure clarity and content validity of the questions.

It is proposed that future evaluation of attainment of the behavioral objectives of this unit be conducted as follows.

1) Administer the pretest to a sample of undergraduate students who have completed an organic chemistry course but have not taken food preparation courses.

2) Tabulate the number of correct responses for each behavioral objective.

3) Present the self-instructional unit to each student in the sample, allowing them to progress at their own pace through the unit.

4) Upon completion of the unit administer the post test to each student.

5) Tabulate the number of correct responses for each behavioral objective.

6) Analyze difference between the number of correct responses on the pretest and the number of correct responses on the post test for each behavioral objective. (An overall measure of a self-instructional unit's ability to teach is the Gain Score or Modified Gain Score as discussed by Mager, 1967.)

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APPENDIX B

Pre- and Post Tests for Proposed
Evaluation of Behavioral
Objectives

PRETEST

Circle the letter of the response which best answers the question or completes the statement.

1- In the structural formula of an amino acid the amino group and the carboxyl group are attached to
   a) the same carbon atom
   b) adjacent carbon atoms
   c) a sulfur atom
   d) opposite ends of a 5-carbon chain

2- A high molecular weight, organic compound composed of amino acids linked together by peptide bonds to form polypeptide chains is
   a) protein
   b) carbohydrate
   c) fat
   d) thiamine

3- Proteins can react as
   a) bases only
   b) acids only
   c) acids or bases
   d) neutral substances only

4- Unfolding or uncoiling as well as dissociation of polypeptide chains describes
   a) protein hydrolysis
   b) protein denaturation
   c) intramolecular bonding
   d) protein synthesis

5- Most meat proteins are denatured by heating to a temperature of
   a) 80 - 100°F
   b) 140 - 160°F
   c) 175 - 195°F
   d) 212°F

6- When meat proteins are heat-denatured, muscle fibers
   a) decrease in length and diameter
   b) decrease in length only
   c) decrease in diameter only
   d) do not change

7- Decreases in muscle fiber diameter are associated with
 a) reduced water-holding capacity
 b) increased water-holding capacity
 c) increased pH
 d) decreased pH

8- Connective tissue is composed of
 a) collagen only
 b) elastin only
 c) collagen and elastin
 d) neither collagen nor elastin

9- A beef roast containing large amounts of connective tissue will be more tender if it is
 a) braised
 b) roasted
 c) deep-fat fried
 d) broiled

10- The principle pigment responsible for the color of raw meat is called
 a) myoglobin
 b) hemin
 c) hemichrome
 d) globin

11- What color pigment reaction occurs when meat is exposed to air?
 a) myoglobin changes to oxymyoglobin
 b) myoglobin changes to globin
 c) oxymyoglobin changes to globin
 d) oxymyoglobin changes to myoglobin

12- The brownish-red pigment of meat is
 a) metmyoglobin
 b) oxymyoglobin
 c) hemichrome
 d) nitroso myoglobin

13- A pigment which develops with continued application of heat is
 a) hemichrome
 b) metmyoglobin
 c) nitroso myoglobin
 d) oxymyoglobin

14- Fat melted during the cooking of a piece of meat may
 a) accumulate as drip
 b) evaporate
 c) add caloric value to the meat
 d) increase the keeping quality of the meat

15- Moisture losses from meat during cooking may be retarded by
- a) surface fat
- b) surface browning
- c) high temperatures
- d) long cooking

16- When muscle protein is heat denatured
- a) immobile water is released
- b) bound water is released
- c) water is unaffected
- d) immobile and bound water are released

17- Water present in meat may function as
- a) a solvent for vitamins and minerals
- b) a solvent for fat
- c) precursor of vitamins and minerals
- d) precursor of protein

18- What happens to water in meat when heat is applied?
- a) evaporates or accumulates as drip
- b) evaporates only
- c) accumulates as drip only
- d) none of these

19- In general, what is the relationship between juiciness of cooked meat and the moisture losses from meat during cooking?
- a) direct relationship
- b) indirect relationship
- c) no relationship
- d) positive relationship

20- Minerals extruded from meat during cooking are
- a) retained on the meat surface or transferred to the drip
- b) always retained on the meat surface
- c) always transferred to the drip
- d) evaporated

21- The heat resistance of B vitamins in meat is affected by
- a) cooking time
- b) shape of meat cut
- c) cooking media
- d) all of above

22- Thiamine, the predominate B-vitamin in meat is
- a) heat stable
- b) photolabile
- c) photo stable
- d) heat labile

23- How is the cooking time for meat affected by the presence of bone?
- a) greatly reduced
- b) unaffected
- c) slightly reduced
- d) increased

24- Procedures for cooking meat may be classified as
- a) dry or moist heat methods
- b) dry heat methods
- c) moist heat methods
- d) low and high temperature methods

25- What is the recommended temperature for roasting meat?
- a) 250 to 300°F
- b) 300 to 350°F
- c) 350 to 400°F
- d) above 400°F

26- When meat is cooked in liquid, the temperature of the liquid should be
- a) 150°F
- b) 190-200°F
- c) 212°F
- d) 220°F

27- In general, when high temperatures are used for cooking meat, cooking losses are
- a) the same as when low temperatures are used
- b) increased
- c) decreased
- d) none of these

28- Dry heat cooking is recommended for meat cuts containing
- a) minimal amounts of connective tissue
- b) extensive amounts of connective tissue
- c) minimal amounts of fat
- d) extensive amounts of fat

29- As an indicator of the degree of doneness of a cut of meat, cooking time is
- a) very accurate
- b) an approximate indication
- c) unrelated
- d) none of these

POST TEST

I. Write in the missing word in the following questions.

1- Proteins are termed amphoteric because their acidity or basicity depends upon the number of carboxyl groups in relation to the number of amino groups.

2- An alteration in the structure of a "native" protein which is characterized by unfolding or uncoiling of polypeptide chains and/or dissociation of the protein into smaller units by breaking intramolecular bonds and/or van der Waals forces is defined as protein denaturation.

3- Most meat proteins are denatured when heated to a temperature of 60 ^{o}C.

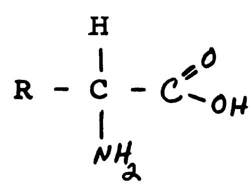
4- Meat is about 70% water. This water may be retained in raw muscle in two ways: 1) chemically bonded and 2) physically immobile.

5- During heat denaturation, minerals in the meat may be extruded, these minerals may be retained on the meat surface or transferred to drip.

6- When heat is applied to meat in the presence of water collagen is hydrolyzed and converted to gelatin.

II. Short answer.

1- Below is the incomplete structural formula of a single amino acid. Complete the structure by attaching any missing groups.



2- Illustrate how the units or building blocks of a protein are linked and the shape usually resulting from the linkages.

Amino acids linked together by peptide bonds to form polypeptide chains which are maintained in a folded or coiled position.

3- What dimensional changes occur to muscle fibers as muscle protein denatures?

Muscle fibers decrease in length and diameter.

4- What causes muscle fibers to decrease in diameter as the muscle protein denatures?

Shrinkage, as the water-holding capacity of the protein is reduced.

5- While some of the B vitamins in meat are destroyed by heat, their resistance is modified by other factors. List four of these factors.

1) cooking time
2) pH of cooking media
3) size of meat cut
4) cooking temperature

6- List the seven procedures for cooking meat and place an "M" in front of those procedures which are moist heat methods and "D" in front of those which are dry heat methods.

D 1) roasting
D 2) broiling
D 3) pan broiling
D 4) deep fat frying
D 5) pan frying
M 6) braising
M 7) stewing

7- You are preparing to cook two similar cuts of meat except one contains large amounts of surface and intramuscular fat. If they are cooked under identical conditions to the same end point temperature, predict which roast will have the greatest cooking losses and give a reason for your answer.

The roast containing large amounts of fat will have the greatest cooking losses because fat melts when heat is applied and can accumulate as drip.

8- After cooking many roasts, you observe that roasts with extensive layers of surface fat generally cook in less time than roasts without surface fat. Explain how surface fat may decrease cooking time.

Surface fat may serve as a protective coating which inhibits moisture loss and leads to decreased cooking times.

9- You are cooking a roast at 400°F to an internal temperature of 160°F. Your lab partner is cooking a similar roast at 325°F to an internal temperature of 160°F. Predict how the cooking losses of these two roasts will compare.

The cooking losses will be greater for the roast cooked at the higher (400°F) temperature.

10- You have been asked to cook a piece of meat from the rib or loin section of a beef animal. What type of cooking method will you use?

A dry heat cooking method

III. Match the pigment in column B with its description in Column A

A	B
f The principle color pigment of raw muscle	a) globin
	b) nitroso myoglobin
	c) metmyoglobin
d Develops when raw meat is exposed to air	d) oxymyoglobin
	e) hemichrome
	f) myoglobin
c The brownish-red pigment which develops when heat is first applied to raw meat	
e Continued application of heat results in development of	

IV. Place a T or an F before the following statements to indicate whether they are true or false.

1. F Vitamins and minerals are insoluble in the water present in muscle.

2. T Water in muscle may evaporate or accumulate as drip when heat is applied.

3. T Cooking losses are indirectly related to the juiciness of cooked meat.

4. F The heat stability of thiamine is greater than riboflavin which is greater than niacin.

5. F The cooking time for meat is greatly increased by the presence of bone.

6. T The recommended temperature for roasting meat is 300 to 350°F.

7. F In moist heat cooking, the cooking liquid should be boiling.

8. T Total cooking time is only an approximate indicator of degree of doneness.