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DETERMINATION OF PALATABILITY, TENDERNESS, AND VITAMIN RETENTION OF MEAT AND POULTRY COOKED IN A SELECTED OVEN FILM

by

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APPROVAL PAGE

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Palatability, tenderness, and vitamin (thiamine, riboflavin, and vitamin B_6) retention of institutional cuts of meat and poultry cooked in the convection oven in nylon ovenproof film or cooked uncovered were studied. Six replications of two similar roasts, one tight wrapped in nylon oven film and the second unwrapped, were cooked in a forced air convection oven at 177° C. to an appropriate internal temperature. As the roasts reached the end point, they were removed from the oven and allowed to continue cooking outside the oven. Immediately after roasts attained maximum internal temperature, total cooking, drip, and volatile losses were determined. Roasts were then sliced and served for palatability evaluation. Total cooking losses were less for roasts cooked in tight wrap than for those cooked unwrapped with significant differences for pork loin and turkey. Drip losses were significantly higher for pork loin and turkey roasted in oven film than for those cooked uncovered; wrapped rib roast drip loss was less than that for those unwrapped. Volatile loss was significantly higher for uncovered turkey and pork loin than for similar roasts cooked in tight wrap. Ribeye roasts showed a comparable trend. Rib roasts cooked in oven film resulted in greater volatile loss than those unwrapped. Although the difference was not significant, mean servable weight was greater for tight wrapped roasts than those cooked uncovered.

A taste panel independently evaluated each roast sample as to appearance, flavor, tenderness, moistness, and overall acceptability. Taste panel scores indicated little difference in overall acceptability attributable to cooking methods. Generally, though differences were small, overall acceptability was higher for those meats roasted uncovered than for those wrapped in film; turkey was the exception.

Tenderness scores were somewhat greater for rib and ribeye roasts and lower for turkey cooked uncovered than for the tight wrapped products. Unwrapped pork loins were significantly more tender than tight wrapped loins. Uncovered rib and ribeye roasts were somewhat less preferable in appearance; whereas, pork loin and turkey were more preferable than similar tight wrapped roasts. Flavor scores indicated a preference trend toward roasts cooked uncovered, with turkey being the exception. Flavor preference was significantly higher for unwrapped ribeye roasts than for those tight wrapped. There was no significant difference between moistness scores, though unwrapped roasts were more moist than tight wrapped roasts except for turkey. Although not significantly affected by cooking methods, shear values, obtained with a Warner-Bratzler shear apparatus, were somewhat lower (indicating greater tenderness) for pork loin, turkey, and rib roasts cooked in oven film and higher for ribeye roasts than similar roasts cooked uncovered. Thiamine, riboflavin, and vitamin B_6 retention of cooked meats was not significantly affected by cooking methods.

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CHAPTER I

INTRODUCTION

Extensive studies have been conducted to determine the effect of oven roasting methods on meat and poultry cooking losses. As meat is often the most important and costly food item on the menu, cooking methods which reduce cooking time and increase the servable meat portion become important to the food service operator. Those methods become useful only if consumer acceptance and nutrient retention are maintained.

The forced air convection oven differs from the natural convection (conventional) oven because of the insertion of a high speed fan which forces air circulation throughout the oven cabinet. In this study the term "convection oven" will refer to the forced air convection oven, whereas, "conventional oven" will designate the natural convection oven. Researchers have reported advantages for the convection oven roasting of meats such as reduced cooking time, decreased power consumption, and increased yield at low oven temperatures.

The recent development of ovenproof cooking film as a durable, transparent, nylon or polyester tubular film for food service use has led to comparative cooking studies. Investigators have reported reduced cooking time for meat and turkey roasted in oven film as compared with similar roasts cooked in an open pan. The disadvantage reported for beef roasted in oven film was greater cooking loss than for similar roasts cooked in an open pan. Palatability studies indicated no significant difference in overall acceptability of roasts cooked by the two methods. Studies have also shown that tenderness, as determined objectively, was not affected by method of cooking.

Meat is a good source of high quality protein and many B-complex vitamins. Water soluble thiamine, riboflavin and vitamin B_6 are found in cooking water and meat juices. Thiamine is easily destroyed by heat in neutral and alkaline solutions; riboflavin, and vitamin B_6 are heat stable but destroyed by exposure to light. The solubility of these vitamins, combined with their ease of destruction, are important factors to consider in the preparation of meat and poultry roasts. Numerous investigators have reported losses of the water soluble thiamine, riboflavin, and vitamin B_6 in meats as a result of various cooking procedures. Vitamin B_6 consists of a group of three closely related substances, pyridoxine, pyridoxal, and pyridoxamine. Throughout this study, the term vitamin B_6 will be used as the group name; pyridoxine will be used to designate a specific vitamin form. However, as studies reported from the literature are discussed by the present author, the vitamin term used will be that of the original research author(s).

Previously reported meat studies involving oven film have dealt with quality of household cuts of meat. The present study was designed to determine palatability and nutrient retention of institutional cuts of meat and poultry cooked in a convection oven uncovered and in a selected oven film.

CHAPTER II

REVIEW OF LITERATURE

Introduction

More than one hundred million times a day someone consumes a meal or snack away from home. Food is served to consumers in family restaurants, college cafeterias, fast-food service establishments, and hospitals. The main entree (meat or poultry) is the primary attraction of meals, and its selection determines other food that will be served at the same time. Meat is often the most important and costly food item on the menu.

Cooking methods which increase the servable meat portion and reduce cooking time are important to the food service operator only if consumer acceptance is maintained. High vitamin retention of cooked meats is important to the customer who is becoming more nutrition oriented. Palatability, vitamin retention, and cooking losses are influenced by meat cooking methods.

Food service establishments purchase meat in institutional sized quantities for cooking by a variety of heat methods though roasting is the most frequent method of preparation. The investigations reported in the literature are primarily studies of household portions of meat. Few studies have reported the effect of cooking methods on palatability, yield, and vitamin retention of institutional portions of meat. Many investigators have studied factors related to roast yield and palatability of household cuts of meat and poultry, as presented in the following review of the literature.

Convection Oven

Radiation and convection are the two basic means for distributing heat in ovens. In radiation hot air circulates around the outside of the heating chamber and radiates through the lining to the inside of the cabinet. With convection heating hot air from a heat source passes through the cabinet. A forced convection oven differs from the natural convection oven (conventional oven) due to the installation of a high speed centrifugal fan which forces air circulation inside the oven. Heat reaches every surface and corner thereby eliminating the uneven heating found in conventional ovens.

Schoman and Ball (1) reported the effects of oven temperature and air circulation on weight and volume yields of beef roasts. Weight and volume yields were found to be directly related. Yield was reported to be a function of evaporation loss and decreased as temperature and air circulation increased. At low oven temperatures with forced air circulation and at the pressure of saturated steam, yield increased while roasting time decreased.

Funk et al. (2) found that at the same temperature, heat penetration rates were faster in a forced convection oven than in a natural convection oven. Roasts cooked in a forced convection oven required eighteen per cent less time than for conventional roasting of similar loin cuts of beef roasts at the same oven temperature. The advantages reported for forced convection roasting of meat include reduced cooking time, decreased power consumption, and increased yield at low temperatures.

A comparison was made of the palatability, cooking losses, and cooking times of United States Department of Agriculture (U.S.D.A.) Good beef sirloin butts roasted at 93°C. and at 149°C. in gas forced convection ovens. Davenport and Meyer (3) found that the lower oven temperature resulted in reduced cooking time, lower cooking losses, greater yield of servable meat, and lower cost per serving. Oven temperatures were not related to shear values or sensory evaluations of tenderness, juiciness, and flavor.

One of the problems encountered in the use of the convection oven was an increase in total cooking losses of meat as compared with those losses obtained in the conventional oven. Funk *et al*. (2) reported that total cooking losses of the roasts cooked in the convection oven were about twenty per cent higher than losses from those cooked conventionally. In addition, forced convection oven cooked roasts scored slightly lower for all palatability factors except flavor of fat and juiciness than the roasts cooked in a conventional oven. This study also resulted in Warner-Bratzler shear values with no difference between meat cooked in the convection oven and in the conventional oven.

Schock and co-workers (4) investigated the effects of dry and moist heat treatments on selected characteristics of U.S.D.A. Good beef top rounds. The dry heating method (oven roasting) showed the slowest rate of heat penetration and the longest cooking time whereas the moist heating methods (oven braising and pressure braising) showed increasing rates of heat penetration, respectively.

Ferger _et al_. (5) found that total cooking losses of lamb and beef roasts cooked from the frozen state in ovenproof film (moist heat) or by open pan roasting (dry heat) were not significantly different. The researchers also reported few palatability differences between meat cooked by the two methods to the same internal temperature.

Oven Film

Ovenproof cooking film is a heavy gauge polyester or nylon tubular film produced for food service use. Meat is placed in the center of the sleeve and securely wrapped in the film in order to eliminate air from the package. The open ends are tied off with metallic twists or string. Several slits are cut into the top of the film wrapped meat package so that steam formed during the cooking process will be free to escape. The oven film is manufactured in several widths for roasts of different sizes.

The recent development of ovenproof cooking film lead Ruyack and Paul (6) to an investigation of the effect of the use of oven film on cooking losses and other beef roast characteristics when cooked by microwave or conventional electric heating. The investigators found that beef roasts cooked in oven film reached the specified temperature end point more rapidly than uncovered roasts. Cooking losses were increased by the use of polyester oven wrap in both cooking methods. Except for external color, other sensory observations were not significantly different in palatability studies of the roasted meats cooked by the various methods.

Heine and co-workers (7) studied the effect on eating quality of turkey hens roasted in an open pan, ovenproof film, foil wrap or paper bag. Turkeys were cooked in a rotary hearth gas oven to the same internal temperature. The results of the investigation indicated that cooking time and cooking losses were affected by cooking methods. Use of oven film significantly reduced cooking time. Turkey cooked in a paper bag required the longest cooking time whereas open pan and foil wrapped turkeys required intermediate cooking times. Total cooking losses were similar for both the open pan and oven film methods of roasting turkey. The open pan method resulted in a higher volatile loss and a lower drip loss than the oven film method. Tenderness, as evaluated by shear values, was not affected by method of cooking. Sensory evaluation did indicate a greater tenderness of the dark meat which was cooked in open pans and paper bags as compared with that meat cooked in ovenproof film or foil wrapped.

Objective Tenderness Determination

Meat has received considerable attention from research workers as a food in which texture is an important factor of consumer acceptance. Meat is unique among foods because its texture is readily apparent to even the most uneducated consumer. The average palate can differentiate between tough and tender meat and between meat which is juicy and flavorful versus meat which is dry and lacking flavor.

The food researcher has at least two methods available for measuring certain attributes of food, the sensory panel and instruments specifically designed to measure physical and chemical properties of food. Both methods must be adapted and critically evaluated for the particular type of investigation to be conducted.

Shearing devices include one type of instrument used to measure the textural characteristics of tenderness in meats by recording the force required to shear the meat sample. The Warner-Bratzler shear as described by Szczesniak and Torgeson (8) consists of a thin blade with a triangular opening large enough to allow insertation of a cylinder of meat. The meat sample is secured from the test material with an instrument similar to a cork borer. The cylinder of meat sample is then placed in the opening of the blade. The blade is led through a slot between two dull shear bars. Force is applied to the blade and the amount of force required to shear the sample is measured with a dynamometer. The greater the recorded force, the less tender the meat.

Sperring et al. (9) proposed specific requirements for a device used to measure meat tenderness. These requirements include the capacity of the device to measure the tenderness of a small sample of raw or cooked meat, ease and speed of operation, and accuracy with a sample small enough for biopsy.

Deatherage and Garnatz (10) critically compared tenderness results obtained from sensory panel tests and the Warner-Bratzler shear using the same broiled steak. The investigators reported that shear strength by the Warner-Bratzler machine and tenderness measurements by the taste panel both measured some property of meat in a fairly reproducible manner. Results indicated a low correlation between taste panel scores and shear values, therefore the authors concluded that shear strength and tenderness are not the same property of meat but rather that shear strength measures a variable which is related to tenderness of meat.

Sharrah et al. (11) studied the relation of meat sensory attributes of tenderness, texture, flavor, and juiciness to mechanical measurements of shear. A highly trained panel evaluated tenderness (resistance to chewing), texture (coarseness of fibers), juiciness, flavor and chew count on slices, and tenderness on cores from three positions of semimembranous and longissimus dorsi muscles. Tenderness was measured objectively with a Warner-Bratzler shear, a L.E.E.-Kramer shear press, and a modified L.E.E.-Kramer shear press containing a Warner-Bratzler shear-plate attachment. The combined instrument provided the advantage of the small sample size of the Warner-Bratzler and the greater sensitivity of the L.E.E.-Kramer shear press. The investigators reported a high positive correlation for the Warner-Bratzler and the two L.E.E.-Kramer shear press values. The Warner-Bratzler shear values were also more highly correlated with panel scores for tenderness than were the values from either of the L.E.E.-Kramer instruments. Based on the results of the study, the authors concluded that mechanical devices differ in their sensitivity and reproducibility, and appear to measure different properties of meat. Variation of tenderness may exist within the same muscle. Judges (even though highly trained) vary considerably in sensitivity and reproducibility, and have a tendency to give relative judgments within a set of variables. Use of only the correlation coefficient in relating subjective and objective measurements may be insufficient. Further investigation is necessary to establish the amount of variation in shear force that is meaningful in terms of sensory evaluation of texture and tenderness in meat. As yet, food scientists do not know how much samples must differ in pounds of shearing force before they can be differentiated by individual judges. In addition, information is not available as to whether sensory discrimination among samples is more acute within a lower range of shear-force values than within a higher range. The authors also recommended that the same judges participate in all evaluations within a study since differences in sensitivity and reproducibility between judges could easily offset treatment effects. The use of fewer judges and more replications may be of greater value than the reverse situation as recommended by Sharrah and co-workers (11).

Sensory Evaluation

The study of flavor is one of the food research areas in which science has not yet matched everyday experience. All of the senses contribute to the flavor of a food; color, texture, taste, odor, and even sound are parts of food flavor. Mainly, flavor is composed of taste and odor. Of the other qualities that enter into flavor, texture is probably the most important.

None of the objective methods devised so far have succeeded in replacing the human senses in their ability to differentiate between and describe meat texture. Szczesniak and Torgeson (8) suggested that human senses give investigators the advantage of close simulation of normal eating conditions and therefore can be used as a reasonable standard for general consumer acceptance.

Numerical rating or scoring tests are often used in the palatability phase of the meat study. Frequently many quality factors are judged. Boggs and Hanson (12) reported that the quality factors to be scored must be placed on the score sheet in logical order; first the factors the judge estimates by sight, next odor, and finally the factors which cannot be scored until the food is taken into the mouth. Any score sheet which simplifies recording and leaves the judge free to concentrate on decisions is a distinct advantage to the study. Mental discipline and training are necessary to separate and evaluate meat quality factors independently.

Sharrah et al. (11) reported that judges demonstrated a close association between sensory attributes of tenderness, texture, juiciness, and flavor. The investigators suggested that the relation was probably due to several factors, including the influence of moisture content upon apparent tenderness and flavor quality, the inability of some of the judges to distinguish between tenderness and texture and the tendency to score attributes either all high or all low. The authors suggested that the tendency to score all attributes either high or low could be partially corrected by evaluating the quality factors individually on separate samples of meat.

Kotschevar (13) reported that certain rules have been laid down for use in the selection of taste judges, some of which apparently evolved empirically. The investigator found no significant sex difference in taste acuity which does not support the claim that women are better tasters than men. Age has also been implicated by some researchers as a factor in poor taste perception. Kotschevar reported data which gave no evidence of taste deterioration with increasing age. Additionally, based on the conditions of the reported study, there was no evidence to indicate that previous illness from hay fever or sinus caused any later failure in taste acuity.

Thiamine and Riboflavin Retention

Meat, like most other foods of animal origin, is a good source of high quality protein and most of the B-complex vitamins. Thiamine and riboflavin are water soluble vitamins found in cooking water and meat juices. Thiamine is readily destroyed by heat in neutral or alkaline solutions. Riboflavin is heat stable but is destroyed by exposure to light. The solubility of thiamine and riboflavin coupled with the ease of their destruction are important considerations because overcooking food, prolonging exposure to light, and discarding the cooking water or juices in which the food was cooked may cause large amounts of the vitamins to be lost. Lean pork is one of the best sources of thiamine for man. Other lean meats contribute valuable amounts of thiamine and riboflavin to the diet. Numerous investigators have reported a loss of the water soluble vitamins, thiamine and riboflavin, in meats as a result of various cooking procedures.

Michelsen *et al*. (14) reported in 1939 one of the earliest studies on the stability of thiamine under various types of cooking methods. A biological method of assaying cooked meats for their thiamine content was described. The biological method was based on a comparison of the growth of rats on a basal ration containing the meat to be assayed with the growth of rats on the basal ration with added amounts of crystalline thiamine. The authors found that there was a slight destruction of the vitamin during frying, but with roasting, broiling or stewing, the destruction of thiamine approached fifty per cent.

McIntire and co-workers (15) investigated the retention of thiamine and riboflavin in pork loin and ham samples cooked under standard conditions. Paired loins were roasted, braised, and broiled; whereas, fresh ham cuts were roasted and broiled. A microbiological method was used to determine riboflavin retention. Thiamine retention was determined by a fluorometric method. Mean thiamine retention was seventy per cent after roasting and broiling and fifty per cent after braising. The mean riboflavin retention was eighty-five per cent as a result of studied cooking methods.

Cheldelin _et al_. (16) determined the percentage of riboflavin loss from meats due to cooking by a microbiological assay method in 1943. The losses during cooking tended to be greatest in the presence of light. Open pan fried pork chops incurred riboflavin losses as high as thirty-three per cent of the raw pork chop value.

Cover and associates (17) determined the vitamin losses in rare and well-done beef rib roasts. Roasts were cooked uncovered until the internal temperature of the meat reached the rare or well-done stage. Thiamine and riboflavin were determined by fluorometric procedures. Thiamine retention averaged seventy-five per cent in rare roasts and sixty-nine per cent in those well-done. Mean riboflavin retention of the rare roasts was eighty-three per cent and seventy-seven per cent for those well-done. Significant differences between animals in thiamine and riboflavin content of raw meat were noted by the investigators.

A study of the effect of roasting pork loin muscles to a constant internal temperature of 85° C. on the thiamine and riboflavin retention was undertaken in 1944 by Brady and associates (18). The researchers analyzed the ribeye muscles and the tenderloin muscles for both thiamine and riboflavin by fluorometric methods. The data indicated the riboflavin content of the raw tenderloin muscle was two times that of the uncooked ribeye muscle. The riboflavin content of the cooked loin muscles was found to be approximately eighty per cent of that found in the uncooked samples. The thiamine contents of the ribeye muscle in the lumbar and thoracic regions of the ribeye muscle were significantly different, the lumbar region containing more thiamine than the thoracic region of the muscle. Thiamine content of the cooked loin muscles was approximately seventy to eighty per cent of that found in the uncooked muscles. The authors emphasized the need for standardized sampling techniques in studies of the riboflavin and thiamine contents of pork roasts because of the significant differences in the vitamin content of various muscles as well as in different sections of the same muscle.

Rice _et al_. (19) determined the thiamine, riboflavin, niacin, and pantothenic acid contents of twenty-four pork muscles for each of several animals. Muscles which contained high levels of thiamine in one animal also contained high thiamine levels in the other animals studied. Similar results were reported for riboflavin. Those muscles which were found to contain large amounts of thiamine contained, in contrast, small amounts of riboflavin. Therefore, the investigators suggested an inverse relationship between thiamine and riboflavin concentration in pork muscles.

Hartzler *et al*. (20) determined the thiamine, riboflavin, and niacin concentration of raw and cooked samples of the shoulder, loin, and liver of five grain-fed pigs and five garbage-fed pigs. Pork shoulders were roasted to a constant internal temperature in a moderate oven temperature. Loins were made into chops and pan fried by low heat. Liver was pan fried at a low temperature. No difference was found between the riboflavin and niacin levels of the two groups of pigs but thiamine levels differed. The shoulder, loin, and liver tissue from garbage-fed animals contained only forty-one, forty-one, and sixty-eight per cent, respectively, as much thiamine as comparable grain-fed animal tissues. The authors suggested that the differences were in line with the thiamine content of the diet rations. Grain ration contained 3 to 4 mcg. of thiamine per gram of diet compared with 2 mcg. of thiamine per gram in the garbage ration.

In addition, the authors determined the thiamine and riboflavin retention of the meats after cooking. Losses of thiamine were large for all samples (sixty per cent for shoulder, forty per cent for loin, and twenty per cent for liver). The large thiamine losses were attributed to longer cooking times. In general, the greater cooking losses occurred in the largest shoulder roasts which required longer cooking times. Riboflavin did not show a significant loss due to cooking.

Mayfield and Hedrick (21) investigated the changes produced by varying the type of ration and the subsequent effect of cooking on the thiamine and riboflavin content of standing rib roasts and lean beef rounds. The researchers found that the effect of feeding grain to range cattle appeared to be an increased fat content of the tissues which became evident after the animals had been on the grain ration for sixty days. Thiamine and riboflavin values were not affected by variations in the feeds studied. Thiamine retention of roasts cooked by a moderate oven temperature was consistently higher than that of roasts cooked at a high oven temperature. The authors suggested that the difference between the retention of the two vitamins was probably due to the greater solubility and heat lability of thiamine as compared with riboflavin.

A study designed to obtain additional information on the losses of thiamine and niacin during cooking of thick and thin cuts of beef by moist and dry heat methods was reported by Cover and Smith (22) in 1956. Paired cuts from four animals were used in the study. Steaks were obtained from the loin and bottom round. Roasts and pot roasts were from the standing rib only. The investigators found a significant difference between the thiamine retention of pot roasts and oven roasts with the thiamine retention being greater for pot roasts. The authors reported that since thiamine is a water soluble vitamin, the retention of the vitamin may be related to the kind of moisture lost during cooking. The loss of moisture is of two kinds, drippings and evaporation. Drippings would carry the vitamins away with the moisture but evaporative loss would not. Evaporation would occur in broiled steaks and oven roasts but not in braised steaks and pot roasts. Evaporation from the surface of meat during cooking by dry heat methods or washing of the surface by condensing steam during cooking by moist heat methods may be important factors which affect thiamine and niacin retention. The investigators suggested that internal temperature may also be an important factor in thiamine retention. Thus, generalizations are difficult to make in relating thiamine retention of beef to cooking temperature, cooking time, or to moisture content of the cooked roasts.

In 1960, Nobel and Gomez (23) reported a study which included the effect of roasting on the thiamine and riboflavin content of retail beef cuts. The effects of roasting temperature and of cooking with the bone in and removed were also considered in the study. Cuts of beef studied were top round, rib, rump, tenderloin, and arm section of the chuck; all meats were U.S.D.A. Choice grade. Roasting was done at 177°C. except for one member of each pair of rib roasts which was roasted at 149°C. to test the effect of roasting temperature on vitamin retention. All cooking was done in an open roasting pan. Thiamine and riboflavin determinations were obtained by fluorometric procedures. The results of the study indicated there was no significant difference in the percentage of moisture, fat, or thiamine retention of standing rib roasts cooked at low (149°C.) and moderate (177°C.) oven temperatures. Additionally, there was no significant difference in thiamine, riboflavin, fat, or moisture retention of bone in and boneless roasts when cooked to an internal temperature of 71°C. at a moderate heat setting. The results suggested that the slightly longer cooking period required at the lower oven temperature and for the boned roasts were not sufficient to cause significantly greater destruction of heat-labile thiamine. The mean thiamine retention was lowest for top round and rib roast, and highest for beef loaf prepared from ground chuck arm. Thiamine retention was intermediate for rump and tenderloin roasts. Mean riboflavin retention was lowest for top round and beef loaf, highest for rib roast and intermediate for rump and tenderloin roasts.

Vitamin B_6 Retention

Water soluble vitamin B_6 consists of a group of three closely related substances, pyridoxine, pyridoxal, and pyridoxamine. The three forms are widely distributed in foods and are present in both a free and bound form. The term vitamin B_6 used throughout refers to the three forms. One of the best sources of vitamin B_6 is lean muscle meat. Vitamin B_6 is stable to heat but is destroyed by exposure to light.

In 1944, McIntire and co-workers (24) determined the choline and pyridoxine content of a number of fresh, cooked, and commerically prepared meats. All determinations were made on undried fresh and cooked meats. A modification of a yeast method was used for the determination of pyridoxine. The authors reported pyridoxine retention in meat after various cooking methods ranged from fourteen to forty-two per cent. Roasting and broiling methods resulted in higher pyridoxine retention values than did stewing or braising.

Lushbough *et al*. (25) determined the vitamin content of fresh muscle and organ meats and the retention of vitamin B_6 in cooked and processed meats. The assay of natural foods for vitamin B_6 is complicated by the occurrence of the vitamin in its several natural forms which have varying biological activities for different experimental animals and microorganisms. The investigators used both a microbiological yeast assay and a rat bioassay in the study. Fresh and cooked samples of beef, lamb, veal, and pork and several processed meats were tested for vitamin B_6 content. Paired cuts of meat from the same carcass were selected. One of each pair was roasted until the well-done stage was attained. The investigators found that when compared to sterilization by microfiltration, autoclaving was without significant effect on the vitamin B_6 activity of a pyridoxine standard solution, the basal medium, or the meat samples tested in the experiment. Values obtained for the vitamin B_6 content of fresh meats, using the Saccharomyces carlsbergensis yeast method were consistent with earlier reported work. Vitamin B_6 values observed with the rat bioassay were significantly higher. The variances were attributed to possible species differences in the ability to utilize the vitamin B_6 present in fresh, cooked, and processed meat and meat products. The retention of vitamin B_6 in cooked meats averaged fifty-four per cent, a value greater than previously reported. Mean vitamin B_6 retention as determined by the yeast method in standing rib roast was reported as fifty-six per cent; uncured ham retained fifty-seven per cent of the vitamin B_6.

Although vitamin B_6 is considered to be heat-stable, investigators have reported substantial losses during cooking of meat. Because meat is a good source of both pantothenic acid and vitamin B_6, Meyer et al. (26) investigated the effect of cooking on the retention of the two vitamins. The methods of cooking included oven roasting and oven braising. Paired, boneless beef roasts were obtained from the longissimus dorsi muscle of the loin and semimembranous muscle of the round. Loin roasts were cooked in an uncovered pan while round roasts were oven braised. Total pantothenic acid and vitamin B_6 were measured microbiologically by the yeast growth method in which Saccharomyces carlsbergensis is the test organism. The mean vitamin B_6 retention in oven roasted loin was seventy-two per cent whereas that of the oven braised round was reported to be forty-nine per cent of that in the raw product. Pantothenic acid retention in roasted loin averaged eighty-nine per cent while that of the braised round was fifty-six per cent. The mean vitamin B_6 values for raw and cooked beef loin and round was slightly higher than those previously reported in the literature. Mean retentions of vitamin B_6 in the roasted and braised beef were also higher than reported in earlier studies with beef and other meats. The authors reported that the reasons for the retention differences were not evident but the high retentions did seem to be consistent with the generally recognized heat-stable nature of vitamin B_6.

Summary

Many investigations have been conducted on the effects of cooking temperatures, cooking times, and heat penetration rates on the tenderness, palatability and vitamin retention of retail cuts of meat. As there is a scarcity of data on the nutritive value of institutional sized quantities of meat cooked in the convection oven, studies reviewed here have dealt primarily with household cuts of meat.

CHAPTER III

EXPERIMENTAL PROCEDURES

Introduction

Conventional and microwave ovens have been the energy sources used by investigators in studies of meat roasted in oven-proof cooking film. Ruyack and Paul (6) selected twenty-four U.S.D.A. Choice semitendinosus muscles which were divided into anterior and posterior sections. Each section was roasted by one of the following cooking methods: conventional electric oven, meat unwrapped; conventional oven, meat wrapped in polyester oven film; microwave oven, meat unwrapped; and microwave oven, meat wrapped in oven film. At each end of the wrapped roasts, the film was punctured to allow steam to escape. Electronically cooked roasts showed considerable temperature rise after removal from the oven, while those cooked conventionally showed only a small rise. The temperature rise outside the oven was allowed for in determining when to remove the roasts from the oven. Conventionally cooked meats were heated at 163°C. to an internal temperature of 71° C. Internal temperatures were measured with thermocouples. Roasts cooked in the microwave oven were removed when the temperature was 20°C. below the desired end temperature. Standing time allowed the temperature to reach an average of 71°C.

A taste panel of six judges scored each roast for external and internal appearance and odor. Physical determinations were made on the lean meat from the portion of the roast not used for subjective evaluation (6). Total cooking losses, dripping and volatile cooking losses were determined. Force required to shear was measured on the cooked meat.

Heine, Bowers, and Johnson (7) prepared thirty-six halves from eighteen turkey hens purchased from a commercial source. Turkeys were cooked with or without wraps in a rotary hearth gas oven at 163° C. to an internal temperature of 85° C. in the mid-portion of the pectoralis major muscle. Methods of wrap included an ovenproof film bag, paper bag, or foil wrap. Total cooking time, percentage total cooking loss, volatile loss, and drip loss were determined. Tenderness, juiciness, intensity, and desirability of turkey flavor were evaluated for samples from the breast and thigh muscles by a six member taste panel.

The purpose of this study is to investigate the quality of institutional meat cuts cooked in nylon film or cooked uncovered in the convection oven. A detailed description of the experimental procedures follows.

Procedures

In the summer of 1973, two meat deliveries were received by the School of Home Economics at The University of North Carolina at Greensboro from Armour and Company, a regional commercial meat distributor.

The first delivery included twelve U.S.D.A. Grade 2 fresh pork loins weighing a total of 154.25 lbs. and twelve U.S.D.A. Grade A tom turkeys weighing a total of 319 lb. The second delivery included twelve Armour Star quality beef ribeye rolls weighing a total of 86.5 lb., twelve Armour Star quality beef rib roasts weighing 235.75 lbs., and nine packages of quality ground beef weighing a total of 90 lb. Quality ground beef was defined by Armour and Company, July 1973, as ground beef composed of eighty per cent lean beef and twenty per cent fat. Armour Star quality beef was defined at the same time as being equivalent to U.S.D.A. Good grade beef. The quality of meat selected for this study was representative of meat used in commercial food service. The meat was immediately deposited in a walk-in freezer and held at 0^{o} C. without additional treatment.

Forty-eight hours before roasting, two similar roasts were removed from the freezer unit and placed on aluminum trays for thawing in a cooler maintained at 7^{o} C. Prior to cooking, a portion of the meat was removed to be retained as a raw sample for later vitamin and moisture analyses. The amount of raw sample retained was determined with a yardstick in an attempt to make both roasts to be cooked equal in length. Meat was wiped with a clean cloth and weighed on a laboratory balance scale. All roasts were seasoned with ½ oz. of salt and ¼ oz. of pepper. One roast was placed uncovered in an open aluminum roasting pan. The other was tight-wrapped with ovenproof film. The ovenproof film used in this study is a transparent, heavy duty, tubular, nylon cooking film which is manufactured in several widths for food service use. The product used in this study (Reynolds Ovenproof Film 974) was seventeen inches in diameter. The roast was placed in the center of a film sleeve, and the film was securely wrapped about the meat to eliminate as much air space between the roast and the film as possible. Open ends of the film sleeve were closed with metallic twists to give the meat film package a tight wrap. Six slits were made in the top of the package to allow steam to escape during cooking. The tight wrapped meat was placed beside the unwrapped roast in the same baking pan. A Taylor dial type meat thermometer was placed in the center of each roast for the determination of internal temperature.

Roasts were cooked in the center of a Blodgett Zephaire forced convection oven at 177° C. Roasts cooked in the convection oven continue to increase in internal temperature after they have been removed from the oven. A temperature rise was allowed for in determining when to remove the roasts from the oven. The mean internal temperatures of the meats when removed from the oven were 77° C. for turkey, 76° C. for pork loin, 60° C. for rib roast, and 62° C. for ribeye roll. Meat loaf was prepared from ground beef by a recipe adapted from a standard quantity recipe book by Fowler, West, and Shugart (27). Individual meat loaves were shaped and baked in loaf pans. Five individual loaves were baked uncovered and five loaves were baked in cooking film. All loaves were cooked simultaneously. Meat loaves were removed from the oven when the internal temperature of the center loaf registered 67° C. (see Appendix A - meat loaf recipe).

Roasts were allowed to remain undisturbed at room temperature until the maximum internal temperature was attained. As soon as the temperature began to decrease, the roasts were removed from the oven film and baking pan. Cooked meat weight and dripping weight were recorded. Drip, meat juice, and fat volumes of the drippings were measured in a 250 ml. volumetric cylinder. Weight loss was determined by the equation:

$$\text{Per cent weight loss} = \frac{\text{(Raw meat weight - Cooked meat weight)}}{\text{Raw meat weight}} \times 100.$$

A sample of the data sheet used throughout this study is found in Appendix A.

Roasts were deboned and trimmed of excess fat in order to determine servable weight. Meat was sliced and served to taste panel members.

The mean of three one-half inch longitudinal cores taken from the center of each roast was used to determine objective tenderness of cooked roasts at room temperature. A Warner-Bratzler shear apparatus[1] was used to determine shear values of the meat cores.

A fourteen member taste panel was randomly selected from The University of North Carolina at Greensboro personnel (faculty, staff, and students). The taste panel evaluated cooked meat as to appearance, flavor, tenderness, moistness, and overall acceptability (composite score). Two meat samples (one from each roast) were presented simultaneously. Judges were asked to evaluate each sample independently,

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[1]Manufactured by G-R Electric Manufacturing Company, Manhatten, Kansas.

scoring the five factors according to a scale which ranged from five to one, in which five equals "very good" and one equals "very poor." A sample of the sheet used throughout this study is found in Appendix A.

One week before the subjective evaluation of the cooked meats began, the taste panel members met with the investigator in order to receive a general explanation of the study, and to become familiar with the score sheet used throughout the evaluation period. Although the subjective evaluation was not conducted in a room specifically designed for taste panel work, judges did work independently and in a serious manner. There was no communication among judges during the sample evaluation period. The taste panel met thirty times throughout the experimental period. New taste panel members were added between the first and second summer sessions due to the loss of students, faculty, and staff to vacations. Addition of new panel members was made at the beginning of a beef cooking period.

After subjective testing, cooked and raw roast samples were wrapped in heavy duty freezer paper or in plastic bags and stored in a walk-in freezer maintained at 0° C. In mid-August, 1973, samples were moved to a consumer type upright freezer which was maintained at -8° C.

<u>Thiamine and Riboflavin Extraction</u>

A modified method of Conner and Straub (28) was used to extract thiamine and riboflavin from the meat sample. Since thiochrome and riboflavin are destroyed by light, the entire procedure was carried out in a darkened room.

A sample containing approximately 10 to 30 mcg. of thiamine was weighed and blended at high speed by a ten speed household blender with 100 ml. of 0.04 N sulfuric acid. The liquid was transferred to a 200 ml. or 250 ml. amber volumetric flask with 25 ml. of 0.04 N sulfuric acid. The flask was heated, with intermittent hand mixing, in a boiling water bath for thirty minutes, cooled under running water, and then in an ice bath until the flask and its contents reached room temperature. Ten milliliters of 0.5 per cent buffered (pH = 4.5) Polidase[2] solution was pipetted into the flask and mixed. Appropriate enzyme and reagent blanks were prepared. The flask was incubated at 37° C. for a twenty-four hour period. Following incubation, the flask was brought to volume with distilled water, filtered, and stored in aluminum foil covered glass bottles. The filtrate was stored in a chest type freezer maintained at 0° C.

Thiamine Determination

Thiamine content of raw and cooked meat and poultry was determined by an adaptation of the thiochrome procedure of Conner and Straub (29). The thiochrome procedure depends upon the oxidation of thiamine to thiochrome, which fluoresces in ultraviolet light. If standardized conditions are employed, in the absence of other fluorescing substances, the fluorescence is proportional to the amount of thiochrome present in

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[2] Purchased from Schwarz BioResearch, Inc., Orangeburg, New York.

the solution and also to the amount of thiamine in the original sample solution.

Two thiamine standards were included with each set of sample determinations. A 5 ml. aliquot of filtrate was pipetted onto an adsorption tube packed with activated Decalso which had been acidified by three per cent acetic acid. Decalso adsorbs thiamine from solution. After the sample had been placed on the column, three 10 ml. portions of hot distilled water were used for washing thiamine through the column. Thiamine was then eluted from the Decalso column with hot acid potassium chloride and collected in a 50 ml. volumetric flask which was made to volume with acid potassium chloride. Thiamine in a 5 ml. aliquot of purified solution from the Decalso column was oxidized to thiochrome by alkaline potassium ferricyanide. As thiochrome is soluble in isobutanol, 10 ml. of isobutanol was added immediately. The thiochrome-isobutanol mixture was agitated for one minute and the aqueous layer was removed by siphoning. Anhydrous sodium sulfate was added to remove excess water before the sample was centrifuged in a refrigerated chamber (20° C.) at 1500 revolutions per minute for three minutes. A blank was prepared for each sample. Following instrument standardization, the fluorescence of the isobutanol solution was determined by a fluorometer.[3] Primary filter 7-60 and secondary filters 47B plus 2A were used, and fluorescence of the isobutanol solution was measured by the number

[3]G. K. Turner Model 111, G. K. Turner Associates, Palo Alto, California.

of dial deflections which occurred on a scale of one hundred divisions. Thiamine content of the sample was calculated by the following equation:

$$\text{Micrograms of thiamine per gram of sample} = \frac{(R - Bl)\ (K)\ (DF)}{\text{sample weight in grams}}$$

where K = micrograms of thiamine per dial deflection,

R = instrument reading of sample,

Bl = instrument reading of sample blank,

and DF = dilution factor of the sample.

Thiamine retention was calculated by the equation: Per cent thiamine

$$\text{retention} = \frac{\text{micrograms of thiamine per gram of cooked sample}}{\text{micrograms of thiamine per gram of raw sample}} \times 100.$$

Riboflavin Determination

Riboflavin content of raw and cooked samples was determined by the method of Peterson, Brady, and Shaw (30). Riboflavin is a bright yellow, fluorescent, water soluble vitamin which is stable in acid solutions. The vitamin is oxidized by potassium permanganate (at pH 4.5 there is less than 10 per cent destruction in ten minutes) as well as reversibly reduced to a non-fluorescing compound by sodium hydrosulfite. Riboflavin is sensitive to both visible and ultraviolet light. A 5 ml. aliquot of the original sample filtrate (pH 4.5) was added to a test tube containing 5 ml. of 0.4 per cent acetic acid. One milliliter of one per cent potassium permanganate was added and the sample mixed. Within two minutes, 1 ml. of three per cent hydrogen peroxide was added. The riboflavin solution was gently poured into a fluorometer tube to avoid excess bubble formation. After instrument standardization, fluorescence of the solution was determined by a fluorometer utilizing primary filters 2A plus 47B and secondary filter 58. After returning the riboflavin aliquot to the remaining quantity in the test tube, 1 ml. of ice cold five per cent sodium hydrosulfite solution was added and the sample mixed. An aliquot was again decanted into a fluormeter tube. The fluorescence of the solution was determined. Intensity of riboflavin fluorescence is proportional to the concentration of riboflavin in the solution. Riboflavin fluorescence is measured as the difference between the fluorescence before and after chemical reduction by sodium hydrosulfite. An appropriate internal standard was used with each sample. Riboflavin concentration and riboflavin retention were determined by the following equations:

Micrograms of riboflavin per gram of sample =

$$\frac{A-C}{B-A} \times \frac{\text{riboflavin increment added}}{\text{aliquot of sample}} \times DF \times \frac{1}{\text{sample weight in grams}}$$

where A = reading of 5 ml. of filtrate plus 5 ml. of acetic acid,

B = reading of 5 ml. of filtrate plus 5 ml. of standard riboflavin solution,

C = reading of filtrate blank,

and DF = dilution factor of the sample.

Per cent riboflavin retention =

$$\frac{\text{micrograms of riboflavin per gram of cooked sample}}{\text{micrograms of riboflavin per gram of raw sample}} \times 100.$$

Vitamin B_6 Determination

Vitamin B_6 is stable to heat, acid, and alkali but is destroyed by light. Thus, the following procedure was carried out in a darkened room. An adaptation of the Atkin, Schultz, Williams, and Frey (31) procedure was used to determine vitamin B_6 retention in cooked meats. This yeast method measures total vitamin B_6 activity in the sample. A sample containing approximately 2 to 4 mcg. of vitamin B_6 was weighed and blended with 50 ml. of warm distilled water at high speed for one minute by a ten speed household blender. The liquid was transferred to a 150 ml. beaker. A total of 39.5 ml. of warm distilled water was used to rinse the blender jar and added to the liquid meat sample. Additionally 0.5 ml. of 10 N hydrochloric acid was added to the blended sample. The beaker was covered with a watch glass and autoclaved[4] for one hour at twenty pounds of pressure (125° C). After autoclaving, the sample was cooled and adjusted to a pH of 4.5 with 15 per cent sodium hydroxide. The sample was transferred to a 250 ml. amber volumetric flask, brought to volume with distilled water, and mixed. To a portion of the sample, one-half teaspoon of Fisher Hyflo Super-cel (diatomaceous earth) was added to aid filtration. The sample was filtered and the filtrate collected in an aluminum foil covered glass jar. Five milliliters of Difco basal pyridoxine-free media plus a solution of the unknown or of pure pyridoxine was placed in a series of test tubes with added distilled water to make the total volume in each tube 9 ml. The tubes were capped and autoclaved for fifteen minutes at fifteen pounds pressure (121° C.), cooled, and inoculated with 1 ml. each of the yeast inoculum,

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[4]Castle Steam Sterilizer Model 1250, Castle Company, Rochester, New York.

<u>Saccharomyces</u> <u>uvarum</u> <u>(carlsbergensis)</u>.[5] The tubes were incubated for eighteen hours at 30° C., and the density of yeast growth estimated in a colorimeter.[6] A standard pyridoxine series was included with each set of samples; the pyridoxine concentration ranged from 0 to 0.04 mcg. per tube. A reference curve was established from the results of the standard pyridoxine concentration series by plotting instrument reading (per cent turbidity) against micrograms of pyridoxine per tube in the standard series. The vitamin B_6 content of the tubes of the unknown sample was determined by interpolation of the per cent turbidity reading on the standard curve. The vitamin B_6 content in each milliliter of test solution was calculated by determining the mean vitamin content for each milliliter of duplicate tubes. Vitamin B_6 content and per cent retention of samples were determined by the following equations:

Micrograms of vitamin B_6 per gram =

$$\frac{\text{mean micrograms of vitamin } B_6 \text{ per milliliter}}{\text{sample weight in grams}} \times \text{DF.}$$

where DF = dilution factor

Per cent vitamin B_6 retention =

$$\frac{\text{micrograms vitamin } B_6 \text{ per gram in cooked sample}}{\text{micrograms vitamin } B_6 \text{ per gram in raw sample}} \times 100.$$

Moisture content of the raw and cooked meat samples was determined according to the Association of Official Agricultural Chemists

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[5]Purchased from American Type Culture Collection, Rockville, Maryland.

[6]Spectronic 20, Bausch and Lomb Incorporated, Rochester, New York.

method (32). Dry weight was calculated by the following equation:

$$\text{Per cent dry weight of sample} = \frac{\text{sample dry weight in grams}}{\text{sample moist weight in grams}} \times 100.$$

Vitamin retention was calculated on a dry sample weight basis to avoid moisture differences resulting from cooking methods.

Institutional cuts of meat and turkey were cooked in nylon film or cooked uncovered in the convection oven. Total cooking losses, dripping and volatile cooking losses were determined. A taste panel evaluated the cooked products as to appearance, flavor, tenderness, moistness, and overall acceptability. Objective tenderness of the cooked meats was determined by shear force. Additionally, thiamine, riboflavin, and vitamin B_6 retention of cooked meats was determined.

CHAPTER IV

RESULTS AND DISCUSSION

Introduction

Previous reports indicate that meat cooking losses are affected by cooking methods. Heine et al. (7) reported greater total cooking loss and drip loss but less volatile loss for turkey hen halves which were roasted in ovenproof film bags than for turkey halves open pan roasted in a gas hearth rotary oven at 163° C. The investigators found no differences in shear values or flavor scores which were attributable to cooking methods. Ruyack and Paul (6) reported similar results with U.S.D.A. Choice grade semitendinosus muscles cooked in polyester oven film or cooked uncovered in either a conventional or a microwave oven.

Proposed Hypothesis

In designing the present study, the hypothesis was made that there would be no significant differences between meats roasted in nylon ovenproof film or open pan roasted in the convection oven. Meat characteristics were evaluated by palatability scores and shear force values. Percentage of water soluble thiamine, riboflavin, and vitamin B_6 retained during cooking was determined. Two sample means assumed to be drawn from normally distributed populations having equal variances were compared; therefore, the t ratio was appropriate. The t statistic was used to determine significant differences between sample means. A two-way analysis of variance (with replication) was used to test the hypotheses concerning the independent variables, cooking methods and judges, their interaction, and the effect of replication. Significance of differences was determined by the F statistic.

Preliminary Study

In a preliminary study, institutional sized top round roasts (defined by Armour and Company as equivalent to U.S.D.A. Choice grade) were cooked in nylon oven film or cooked uncovered in a convection oven to the internal temperature of 49° C. The roasts were then removed from the oven and allowed to reach maximum internal temperature outside the oven before slicing. Three oven temperatures were investigated, a low setting (121° C.), medium (177° C.), and a high setting (205° C.). Percentage of total cooking loss, drip, and volatile losses was determined. A six member taste panel evaluated the roasts for palatability. The score sheet devised for the preliminary study proved acceptable for palatability evaluation and was used throughout the present study (see Appendix). Results of the preliminary study indicated there was less total weight and drip loss for meats cooked in oven film than for roasts cooked in an open pan at all three convection oven temperature settings. There was no difference in palatability scores for the roasts cooked by the two methods. As findings were similar for the cooking methods studied at the three oven temperatures and since the high oven setting (205° C.) excessively dried the exterior of the roast cooked uncovered, the middle oven temperature setting (177° C.) was used throughout the present study. In addition, the manufacturer of the oven film used in this study recommended a 177° C. setting for the convection oven. The ground beef was found to be unacceptable in quality and was eliminated from the study after initial trials.

Cooking Times and Temperatures

Mean values for raw weight, temperature, and times for both cooking methods are given in Table 1. The investigator found it impossible to determine the temperature rise which would occur outside the oven for rib and ribeye roasts. The internal temperature at the time of removal from the oven was estimated for the roasts on a length and width basis in an attempt to allow both roasts in each replication to reach a similar degree of doneness after maximum temperature rise had been attained. Roasts cooked unwrapped and those cooked in the oven film presented the same problem. Rib roasts had a mean temperature rise outside the oven of 10° C. with a range of 5.5° C. to 16° C., whereas ribeye roasts had a mean temperature rise outside the oven of 9° C. with a range of 5.5° C. to 14° C. Contrary to a previous report (6), roasts cooked in oven film reached the mean temperature end point less rapidly than those unwrapped. Tight wrapped pork loin required 128 min., rib roast 236 min., and ribeye 158 min.; whereas, uncovered pork loin required 119 min., rib roast 224 min., and ribeye 125 min. for total cooking time. Tight wrapped turkey, which reached the mean internal temperature more rapidly

Table 1: Means of raw weights, cooking temperatures, and times

	wrapped				unwrapped			
	pork loin	turkey	rib roast	ribeye	pork loin	turkey	rib roast	ribeye
raw weight(oz.)	136	354	254	100	133	354	265	97
removal temp. (° C.)	75	76	59	62	77	78	60	62
final temp. (° C.)	81	81	69	71	81	80	71	71
removal time (min.)	100	139	180	116	90	167	174	95
total cooking time (min.)	128	169	236	158	119	195	224	125

N = 6 replications

(169 min.) than unwrapped turkey (195 min.) was the exception. Heine et al. (7) reported similar cooking time differences for wrapped and unwrapped turkey halves.

Cooking Losses

Table 2 shows the means and t values for total cooking, drip, and volatile losses. The results do not support previous findings (6, 7) that total cooking losses for meat and turkey cooked in oven-proof film were greater than for meat and turkey cooked uncovered. The results of this study indicated less total cooking loss for those roasts cooked in tight wrap (pork loin 22.0 per cent, turkey 29.7 per cent, rib roast 28.5 per cent, and ribeye 28.3 per cent) than for those cooked uncovered (30.4 per cent, 37.0 per cent, 29.4 per cent, and 29.2 per cent, respectively). The difference was significant at $p \leq 0.05$ for pork loin and $p \leq 0.01$ for turkey. Differences in total cooking losses were not significant for rib roasts or ribeye roasts, though the same trend was evident. Drip losses were significantly higher ($p \leq 0.05$) for tight wrapped pork loin (44.2 per cent) than for similar roasts (18.9 per cent) cooked in the open pan. Turkey losses were also significantly higher ($p \leq 0.01$) in tight wrap. Although the difference was not significant, the drip loss from rib-eye roasts (31.3 per cent) cooked in tight wrap was greater than that for ribeye roasts (25.3 per cent) cooked uncovered. Rib roasts cooked in oven film showed less drip loss (40.0 per cent) than those cooked uncovered (45.5 per cent). Volatile loss was significantly less for pork loin ($p \leq 0.05$) and turkey ($p \leq 0.01$) cooked in oven

Table 2: Mean values and t values for cooking, drip, and volatile losses

	wrapped roasts	unwrapped roasts	t
cooking loss (%)			
pork loin	22.0	30.4	2.32*
turkey	29.7	37.0	4.74**
rib roast	28.5	29.4	<1
ribeye	28.3	29.2	<1
drip loss (%)			
pork loin	44.2	18.9	2.61*
turkey	58.7	14.1	7.57**
rib roast	40.0	45.4	<1
ribeye	31.3	25.3	2.10
volatile loss (%)			
pork loin	55.8	81.1	2.61*
turkey	41.3	85.8	7.56**
rib roast	60.0	54.6	<1
ribeye	68.8	74.7	2.02

*Significant ($p \leq 0.05$)

**Highly significant ($p \leq 0.01$)

N = 6 replications

film than for those roasts cooked uncovered. Ribeye roasts showed a similar trend but the difference in volatile loss was not significant (68.8 per cent for tight wrap and 74.7 per cent for uncovered). Wrapped rib roasts (60.0 per cent) had greater volatile losses than did those unwrapped (54.6 per cent). Table 3 presents means and t values for servable weight and shear force. Mean servable weight was greater, but not significantly, for tight wrapped roasts than for those unwrapped. The servable weight for tight wrapped pork loin was 51.5 per cent, turkey 36.2 per cent, rib roasts 34.5 per cent, and ribeye 71.7 per cent; contrasted with 42.6 per cent, 32.7 per cent, 33.5 per cent, and 70.8 per cent for similar uncovered roasts.

Shear Force Values

Force required to shear is considered to be an estimate of the ease or difficulty of chewing (tenderness). Mean shear force values are found in Appendix B. Mean shear values (expressed in pounds of force required to sever a meat core) of pork loin (4.4 lb.), turkey (3.8 lb.), and rib roasts (3.9 lb.) cooked in oven film are lower (indicating greater tenderness) than those roasts (5.4 lb., 4.0 lb., and 4.2 lb., respectively) cooked uncovered. Although not significantly different, mean shear values were greater for ribeye roasts cooked in tight wrap (3.8 lb.) than for those cooked in an open pan (3.7 lb.). The finding that shear force values were not significantly affected by the cooking methods used in the present study supports previous reports (6.7).

Table 3: Mean values and t values for servable weight and shear force

	wrapped roasts	unwrapped roasts	t
servable weight (%)			
pork loin	51.1	42.6	1.91
turkey	36.2	32.7	< 1
rib roast	34.5	33.5	< 1
ribeye	71.7	70.8	< 1
shear force (lb.)			
pork loin*	4.4	5.4	1.01
turkey*	3.8	4.0	< 1
rib roast	3.9	4.2	< 1
ribeye	3.8	3.7	< 1

N = 6 replications

*N = 5 replications

Palatability Scores

Inspection of the taste panel scores showed little difference in overall acceptability of the roasts. Table 4 shows the means and F values for composite scores and tenderness. In table 5, the mean scores for appearance, flavor, and moistness are shown. Although differences were small, overall acceptability scores were higher for those meats cooked in the open pan (pork loin 3.8, rib roast 4.1, and ribeye 4.0) than for those cooked in the oven film (3.6, 3.9, and 3.8, respectively) with the exception of turkey which showed no difference in overall acceptability (3.4). Mean tenderness scores were slightly higher for rib roast (4.0) and ribeye (3.7) and slightly lower for turkey (3.3) cooked uncovered than for similar roasts cooked in tight wrap (3.8, 3.6, and 3.4, respectively). There was a significant difference ($p \leq 0.05$) in the tenderness scores for pork loin. The tight wrapped pork loin roasts were less tender (3.5) than the roasts cooked uncovered (4.0). The difference in tenderness may be attributable to higher drip loss of tight wrapped pork loins (44.2 per cent) than those cooked unwrapped (18.9 per cent). Cover (33) suggested that moisture may play as great a part in the tenderness of muscle fibers as it appears to do in connective tissue. Tight wrapped rib and ribeye roasts were somewhat preferable in appearance (4.1 and 4.0 compared to 4.0 and 3.9 for uncovered roasts). However, tight wrapped pork loin and turkey were slightly less preferred than similar roasts cooked in an open pan. Appearance differences were not significantly affected by cooking method. Again, with the exception

Table 4: Means and F values of overall acceptability (composite scores) and tenderness scores

R=6

	wrapped	unwrapped	F
composite score			
pork loin (J=8)	3.6	3.8	2.1
turkey (J=5)	3.4	3.4	<1
rib roast (J=5)	3.9	4.1	1.15
ribeye (J=7)	3.8	4.0	2.6
tenderness			
pork loin (J=8)	3.5	4.0	7.01*
turkey (J=5)	3.4	3.3	<1
rib roast (J=5)	3.8	4.0	1.79
ribeye (J=7)	3.6	3.7	<1

*Significant ($p \leq 0.05$)

R = number of replications
J = number of judges

Table 5: Mean scores for appearance, flavor and moistness

R=6

	wrapped	unwrapped
appearance score		
pork loin (J=8)	4.0	4.1
turkey (J=5)	4.0	4.1
rib roast (J=5)	4.1	4.0
ribeye (J=7)	4.0	3.9
flavor score		
pork loin (J=8)	3.3	3.5
turkey (J=5)	3.4	3.2
rib roast (J=5)	3.9	4.0
ribeye (J=7)	3.9	4.2
moistness score		
pork loin (J=8)	3.6	3.8
turkey (J=5)	3.1	2.8
rib roast (J=5)	3.8	4.1
ribeye (J=7)	3.6	3.8

R=number of replications

J=number of judges

of turkey, flavor scores indicated a general preference for roasts cooked in the open pan. Tight wrapped turkey received a flavor score of 3.4 whereas uncovered turkey received a 3.2 score. There was a significant difference ($p \leq 0.05$) in flavor scores between cooking methods inasmuch as the unwrapped ribeye roasts (4.2) received higher scores for flavor than did tight wrapped roasts (3.9). All flavor was judged to be "fair" (3) or higher. Moistness scores were not significantly different for any of the roasts cooked by the two methods. However unwrapped roasts other than turkey were more moist than tight wrapped roasts. Unwrapped moistness scores were 3.8 for pork loin, 4.1 for rib roast, and 3.8 for ribeye; whereas scores for similar wrapped roasts were 3.6, 3.8, and 3.6, respectively. Turkey moisture scores were 3.1 for covered and 2.8 for uncovered roasts.

Thiamine Retention

Table 6 shows mean vitamin retention of meats cooked in oven film or cooked uncovered. Thiamine retention was higher for pork loin (69 per cent) and rib roast (69 per cent) cooked uncovered than for similar tight wrapped roasts which retained 50 and 60 per cent thiamine, respectively. Tight wrapped turkey retained more thiamine (80 per cent) than did open pan roasted turkey (48 per cent). Although large differences were observed between mean thiamine retention values of meats cooked in oven film or cooked uncovered, the differences were not significant due to large variation in retention values between similar meat samples. There was no difference between the thiamine retention of ribeye roasts cooked by the two methods (78 per cent). The thiamine retention values in this study are in agreement with results of previous studies which

Table 6: Mean thiamine, riboflavin, and vitamin B_6 retention of cooked meats on a dry weight basis

	wrapped				unwrapped			
	pork loin	turkey	rib roast	ribeye	pork loin	turkey	rib roast	ribeye
thiamine retention (%)	50	80	60	78	69	48	69	78
riboflavin retention (%)	70	54	95	75	70	35	89	81
vitamin B_6 retention (%)	72	48	37	46	60	64	83	59

reported the thiamine retention of roasts cooked by dry and moist heat methods. Brady _et al_. (18) reported the thiamine content of roasted loin muscles was 70 to 80 per cent of that found in the uncooked muscles. McIntire _et al_. (15) reported thiamine retention values of 64 to 73 per cent after roasting pork loins. Cover and Smith (22) reported thiamine retention of 41 per cent for rib roasts cooked uncovered and 49 per cent for rib roasts cooked by braising (covered). Mayfield and Hendrick (21) reported thiamine retention of 54 to 64 per cent when rib roasts were cooked by an open pan method.

Riboflavin Retention

Riboflavin retention was higher (81 per cent) for ribeye roasts cooked uncovered than for those tight wrapped (75 per cent). Riboflavin retention of turkey (35 per cent) and rib roast (89 per cent) cooked uncovered was lower than that of similar wrapped products (54 and 95 per cent, respectively). Large differences between mean riboflavin retention values of meats cooked by the two methods were not significant due to large variation in retention values between sample replications. There was no difference between the riboflavin retention (70 per cent) of pork loins cooked uncovered or in oven film. Riboflavin retention reported in the present study supports the results of previous investigations. Brady _et al_. (18) reported riboflavin retention of cooked pork loin roasts as being 80 per cent. McIntire _et al_. (15) reported riboflavin retention of cooked pork loin to be 85 per cent with ranges from 76 to 100 per cent. Hartzler _et al_. (20) reported riboflavin retention in pork loins after roasting to be 99 to 101 per cent. Mayfield and Hendrick (21) reported riboflavin retention of rib roasts cooked uncovered as ranging from 83 to 102 per cent. Noble and Gomez (23) reported mean riboflavin retention of 88 per cent for rib roasts cooked uncovered in a conventional oven. Many authors have reported high riboflavin retention values (greater than 100 per cent) in cooked meats. The present investigator found riboflavin retention values as high as 135 per cent for rib roasts with additional high values including the range of 100 to 133 per cent. Hinman *et al*. (34) investigated the high riboflavin phenomenon and suggested that the results might be due to the release of riboflavin from the precursor or complex when certain cooking procedures involving high temperatures are used.

Vitamin B_6 Retention

Vitamin B_6 retention was higher for turkey (64 per cent), rib roast (83 per cent), and ribeye (59 per cent) roasts cooked uncovered than for those cooked in the oven film. Vitamin B_6 retention values for tight wrapped products were found to be 48 per cent in turkey, 37 per cent in rib roast, and 46 per cent in ribeye roasts. Pork loin cooked unwrapped resulted in lower vitamin B_6 retention (60 per cent) than did pork loins cooked in the nylon film (72 per cent). Again, large differences between mean vitamin B_6 retention values of meats cooked by the two methods were not significant due to large variation in retention values between sample replications. Lushbough *et al*. (25) reported vitamin B_6 retention as 56 per cent for rib roasts cooked uncovered in a conventional oven. McIntire *et al*. (24) reported retention of pyridoxine in various cuts of meat after cooking which ranged from 14 to 42 per cent. Mayer *et al*. (26) reported mean vitamin B_6

retention in oven roasted beef loins as 72 per cent with a range of 61 to 80 per cent. Oven braised round roasts resulted in vitamin B_6 retention ranging from 45 to 52 per cent with a mean of 49 per cent, higher total vitamin B_6 retention values than previous investigators had reported. These same authors suggested that high retention values reported were consistent with the generally recognized heat stable nature of vitamin B_6. The present investigator also found high vitamin B_6 retention values which ranged from 87 to 107 per cent. The present study is in agreement with previous investigations which reported vitamin B_6 retention of cooked meats. The data showed a range of values, but there was no significant difference in vitamin B_6 retention due to the cooking methods utilized in this study.

Large variation in vitamin retention values between sample replications was noted by the present investigator. Vitamin retention values are found in Appendix B. One source of variation could be in sampling technique. Brady and associates (18) reported significant differences in thiamine and riboflavin content of various pork loin muscles as well as in different sections of the same muscle. A second source of variation could be due to differences in the rate of heat penetration which depends on sample size and conformation, distribution of lean, fat, connective tissue, and bone (6).

CHAPTER V

SUMMARY AND CONCLUSIONS

Summary

The palatability, tenderness, and water soluble thiamine, riboflavin, and vitamin B_6 retention of institutional sized quantities of meat and poultry cooked in the convection oven in nylon ovenproof film or uncovered were studied. Six replications of two similar roasts, one tight wrapped in nylon oven film and the second unwrapped, were cooked at 177° C. to an appropriate internal temperature in the convection oven. At the end point roasts were removed from the oven and allowed to reach maximum internal temperature (post oven cooking).

Total cooking, drip, volatile losses, and servable weight were determined before slicing. Total cooking losses were less for roasts cooked in oven film than for those cooked uncovered. The difference was significant for pork loin and turkey but not for rib roast or ribeye although the same trend was evident. Drip losses were significantly higher for pork loin and turkey roasted in tight wrap than for similar unwrapped meats. Although the difference was not significant, drip loss from ribeye roasts cooked in oven film was greater than for those cooked uncovered. Tight wrapped rib roast drip loss was less than that of those unwrapped. Volatile loss was significantly less for pork loin and turkey cooked in oven film than for those roasts cooked uncovered. Ribeye roasts showed a similar, but non-significant trend. Tight wrapped rib roasts resulted in greater volatile loss than did unwrapped roasts. Mean servable weight was greater, though not significant, for tight wrapped roasts than for those cooked unwrapped.

One half inch cores were taken from the center of each roast. Meat tenderness was determined objectively by the force (pounds) required to sever a meat core with the dull edge of an aluminum triangle from the Warner-Bratzler shear apparatus. Shear values were not significantly affected by cooking method; however, mean shear values of pork loin, turkey, and rib roasts cooked in nylon oven film were lower than those of unwrapped roasts. Shear values of ribeye roasts cooked in tight wrap were greater than those of roasts cooked in an open pan.

Slices of roast were served to a panel of judges who independently evaluated each sample as to appearance, flavor, tenderness, moistness, and overall acceptability. Taste panel scores showed little difference in overall acceptability attributable to cooking methods. Generally, although differences were small, overall acceptability was higher for those meats cooked uncovered than for those tight wrapped, with the exception of turkey, which showed no difference between methods. Mean tenderness scores were somewhat higher for rib roast and ribeye and lower for turkey cooked unwrapped than for similar tight wrapped roasts. Uncovered pork loins were significantly more tender than tight wrapped loins. Tight wrapped rib and ribeye roasts were somewhat more preferred as to appearance; whereas, pork loin and turkey were less preferred than those similar roasts cooked in an open pan. Flavor scores indicated a general preference for unwrapped roasts, with turkey being the exception. Flavor differences were significant between tight wrapped and unwrapped ribeye roasts, with unwrapped being preferable. There was no significant difference between moistness scores for the two cooking methods. However, unwrapped roasts were more moist, with the exception of turkey, than tight wrapped roasts.

Thiamine, riboflavin, and vitamin B_6 retention in cooked samples was determined. Vitamin retention was not significantly affected by cooking methods. Mean thiamine retention was higher in uncovered pork loin and rib roast, and lower in turkey than in similar tight wrapped roasts. No difference in ribeye thiamine retention was observed for the two cooking methods. Riboflavin retention was higher in unwrapped ribeye and lower in turkey and rib roasts than in similar tight wrapped meats. No difference was noted between the riboflavin retention of unwrapped and tight wrapped pork loins. Vitamin B_6 retention was greater for uncovered turkey, rib, and ribeye roasts than for those cooked in oven film. Uncovered pork loins retained less vitamin B_6 than did similar nylon film wrapped loins.

Additionally, the investigator observed less oven splattering from roasts cooked in tight wrap than from roasts cooked uncovered. Also, the moisture vapor-proof characteristics of the nylon oven film contribute to its usefulness as a freezer wrap material.

Conclusions

Subject to the conditions of this study, the following conclusions can be made:

1. Total cooking losses were less for roasts cooked in ovenproof cooking film than for roasts cooked uncovered.
2. Mean shear force values were lower (indicating greater tenderness) for tight wrapped roasts, with the exception of ribeye, than unwrapped roasts.
3. Both cooking methods resulted in acceptable products as determined by palatability scores. Overall acceptability differences, though small, tended to slant toward a higher preference for meats cooked uncovered than for those cooked in oven film. The exception was turkey for which no preference was shown between cooking methods.
4. Flavor scores indicated a trend toward preference for all unwrapped roasts but turkey.
5. Unwrapped roasts were somewhat more moist than tight wrapped roasts. Again, the exception was turkey.
6. There was no difference between cooking methods as to thiamine, riboflavin, or vitamin B_6 retention.

Recommendations for Further Investigations

The results obtained in the present study indicate additional research should be conducted on institutional sized quantities of meat and poultry cooked in nylon ovenproof film in the convection oven. As beef other than U.S.D.A. Good grade is served in commercial food service establishments, additional study would be warranted on the palatability, tenderness, and vitamin retention of U.S.D.A. Choice beef roasts (institutional size) cooked in tight wrap in the convection oven.

Because the present investigator found it impossible to accurately determine the outside oven temperature rise which would occur for roasts, additional studies might disregard outside oven cooking and concentrate totally upon cooking within the oven to a specific end point.

The investigator also recommends a lower convection oven cooking temperature (121° C.) for further studies. Uncovered rib roasts and turkeys developed crisp and dry exteriors at 177° C. within the cooking period required to achieve doneness.

Studies of water soluble vitamin retention in drippings of tight wrapped roasts would be of interest as meat juices are used for gravies and soups in commercial food service establishments. Additionally, more closely paired lean roasts or muscles, and a more standardized sampling technique are recommendations for further investigations.

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APPENDIX A

DATA SHEET, SCORE SHEET, AND

MEAT LOAF RECIPE

COOKING TEST DATA SHEET

Test Number ________ Chart Number ________ Date ________

Food

Item (Meat or Recipe) ________ Grade (Meat) ________

Film Wrapping

Width or Size of Film ________ Film Supplier ________

Flour Procedure ________

Wrapping Technique ________ Type Tie ________

Venting Procedure ________

Description of Pan: ________ Pan Size ________

Oven

Type of Oven ________ Oven Temp. Setting _____ Cycle _____

Position of Item or Items in Oven ________

Weights

Starting Weight (Raw) ________

Cooked Meat Weight ________ Time of Weighing (After Removal from Oven) ________

Weight of Drippings ________ Drippings Vol. (Fat + Juice) _____
Fat Vol. (After Settling) _____
Meat Juice Vol. (After Settling) ___

Weight Loss % $\left(\frac{\text{Raw Meat-Cooked Meat} \times 100}{\text{Raw Meat}}\right)$ ________

Times

Time into Oven ________ Starting Internal Temp. of Meat _____

Time out Oven ________ Internal Temp. of Meat Upon Removal from Oven ________

Cooking Time (In Oven) ________

Final Interior Temp. of Meat _____ °F. After Holding (Outside Oven) ________ Min. @ ______ °F.

COOKING TEST DATA SHEET--Continued

Appearance of Meat Before Slicing ______________________________

Final Evaluation

Appearance of Sliced Meat ______________________________

Texture ______________________________

Appearance of Drippings ______________________________

Condition of Film ______________________________

Remarks and Other Observations ______________________________

____

Signed ______________________________

SCORE SHEET USED THROUGHOUT THE STUDY

Instructions: Circle the number which best describes the factor being judged.

Sample No. ___________ Kind: _______________ Date: ____________________

Factor	Very Good=5	Good=4	Fair=3	Poor=2	Very Poor=1
Appearance	5	4	3	2	1
Flavor	5	4	3	2	1
Tenderness	5	4	3	2	1
Moistness	5	4	3	2	1
Composite Grade	5	4	3	2	1

MEAT LOAF RECIPE

15 lb. beef, ground

10 oz. crumbs, bread

12 eggs, beaten

1 qt. milk

¼ c. salt

1 tsp. pepper

Mix ingredients lightly. Do not overmix. Place in 10 loaf pans, L 7¼ in. X W 3½ in. X H 2½ in. inside. Divide each portion into five loaf pans. Bake one portion in tight wrap oven film, bake the second portion uncovered at 177° C. in a convection oven.

APPENDIX B

SHEAR FORCE AND VITAMIN RETENTION DATA

Table 1: Mean shear force values (in lbs.) of meats cooked in oven film and uncovered

	oven film				uncovered			
	pork loin	turkey	rib roast	ribeye	pork loin	turkey	rib roast	ribeye
	4.1	2.6	4.7	5.7	3.8	4.6	3.9	5.4
	4.9	3.7	3.0	2.8	5.8	3.8	4.6	3.1
	6.2	3.2	5.0	4.8	5.4	4.6	5.3	3.9
	3.9	5.0	2.4	3.4	3.6	3.6	3.9	4.2
	—	—	3.8	3.1	—	—	3.2	2.9
grand mean	4.4	3.8	3.9	3.8	5.4	4.0	4.2	3.7

Table 2: Thiamine concentration and retention[1] of meats cooked in oven film and uncovered

	oven film			uncovered		
	mcg./gm.		%	mcg./gm.		%
	raw	cooked	retention	raw	cooked	retention
pork loin	44.3	31.1	70	34.3	24.2	71
	57.4	27.8	49	43.1	22.0	51
	42.9	13.5	31	35.1	29.7	85
mean	48.2	24.2	50	37.5	25.3	69
turkey	3.1	1.7	57	3.0	1.4	47
	3.0	1.8	61	3.4	1.4	40
	1.9	2.3	123	3.5	1.9	55
mean	2.6	1.9	80	3.3	1.6	48
rib roast	3.8	2.2	57	6.4	1.6	25
	2.4	0.7	28	3.0	4.0	135
	2.0	1.9	94	3.4	1.6	47
mean	2.8	1.6	60	4.2	2.4	69
ribeye	3.5	3.5	102[2]	2.4	3.0	123
	1.6	1.4	91	3.2	1.3	41
	4.6	1.9	41	2.7	1.9	70
mean	3.2	2.3	78	2.8	2.1	78

[1]Values are calculated on a dry weight basis.

[2]Apparent discrepency due to rounding off of values.

Table 3: Riboflavin concentration and retention[1] of meats cooked in oven film and cooked uncovered

	oven film			uncovered		
	mcg./gm.		%	mcg./gm.		%
	raw	cooked	retention	raw	cooked	retention
pork loin	3.7	2.4	64	3.5	1.9	53
	2.7	2.7	100	3.6	3.1	84
	3.8	1.8	46	3.3	2.4	73
mean	3.4	2.3	70	3.5	2.4	70
turkey	1.8	1.1	58	2.5	0.5	19
	3.0	1.8	59	3.3	1.9	56
	3.6	1.7	47	3.7	1.1	30
mean	2.8	1.5	54	3.1	1.1	35
rib roast	2.4	1.9	80	1.8	1.6	90
	2.7	1.9	71	1.4	1.7	120
	1.8	2.5	133	2.5	1.4	58
mean	2.3	2.1	95	1.9	1.6	89
ribeye	2.8	2.5	89	3.5	1.4	40
	1.6	1.5	99	1.5	1.5	97[2]
	2.3	0.9	37	1.0	1.1	105
mean	2.2	1.6	75	2.0	1.3	81

[1]Values are calculated on a dry weight basis.

[2]Apparent discrepency due to rounding off of values.

Table 4: Vitamin B_6 concentration and retention[1] of meats cooked in oven film and uncovered

	oven film			uncovered		
	mcg./gm.		%	mcg./gm.		%
	raw	cooked	retention	raw	cooked	retention
pork loin	17.1	18.3	107	19.7	13.0	66
	19.7	16.6	84	17.9	8.6	48
	16.3	3.9	24	11.2	7.5	67
mean	17.7	13.9	72	16.2	9.7	60
turkey	8.3	2.1	26	7.1	6.1	87
	5.1	3.3	66	11.3	3.4	30
	13.2	6.9	52	10.1	7.7	76
mean	8.9	4.1	48	9.5	5.7	64
rib roast	18.0	5.1	28	9.4	5.0	54
	11.3	3.6	31	19.3	17.3	90
	15.3	7.9	52	15.4	16.0	104
mean	14.9	5.5	37	14.7	12.8	83
ribeye	4.4	4.1	94	5.6	5.4	96
	6.4	0.8	13	11.8	5.9	50
	11.3	3.5	31	11.3	3.6	32
mean	7.4	2.8	46	9.6	5.0	59

[1]Values are calculated on a dry weight basis.