EFFECTS OF A POLYPHOSPHATE SALT ON EATING AND MICROBIAL QUALITY OF PRECOOKED AND FRESHLY COOKED TURKEY ROULADES STORED 4 AND 8 WEEKS

by

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TABLE OF CONTENTS

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

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INTRODUCTION

Turkey consumption has increased from over 7 lb per capita in 1963 to 8.3 lb per capita in 1969. Turkey meat presently accounts for only one-fifth of the total poultry meat consumption. Over half of this consumption occurs during October, November, and December (Cathcart, 1971). A challenge to the poultry industry is the development of new poultry products and convenience food items utilizing turkey meat that will further increase the consumption. The demand for new convenience food items has been created by an increasing percentage of women in this country working outside the home with a lack of time or desire for food preparation. Darrah (1967) stated that one out of every four meals is eaten away from home with the result that a large number of people must be fed within a relatively short period of time; hence this fact encourages the demand for convenience foods in food services.

Turkey meat sold traditionally as the whole bird is now increasing in use as cooked turkey meat and combination food products. During the past ten-year period ending in 1966 turkey meat in such products increased 400% (Dawson, 1969). Institutions serve turkey throughout the year. The processing of boneless rolls and turkey parts was a welcome service to those users; however, there is a demand for still smaller portions of the large bird that will enable the service of turkey to small groups. The development of products that could be marketed in smaller portions would help to meet the needs of both the consumer and the food service market.

The objectives of this study were to develop a convenience food (turkey roulades) utilizing turkey muscle and skin; and to study the effects of precooking and reheating roulades and a food grade polyphosphate mixture on the eating quality, thiobarbituric acid (TBA) values, and microbial quality of roulades stored 4 and 8 weeks.

REVIEW OF LITERATURE

Little technical information on products utilizing poultry meat is available as the development of new convenience foods has been performed by commercial companies (Baker et al., 1966; Hasiak and Baker, 1968). The interest in individual portions of turkey meat was stimulated by a temporary surplus of turkeys that developed following World War II (Klose et al., 1950). The preparation and sale of turkey steaks was described by Beanblossom (1948)and Klose et al. (1950) who estimated that from 40 to 52% of the turkey carcass weight was available for steak production.

The use of skin as a potential source of raw material for new turkey products was suggested by MacNeil et al. (1965), who found that skin yields from different strains of turkeys vary from 6 to 12% by weight of the eviscerated carcass. Taylor et al. (1965) incorporated the skin covering the breast and thigh muscles in light and dark meat steaks, and concluded that skin could be used without lowering eating quality. Baker et al. (1968) studied various levels of skin (0 to 50%) on the texture and juiciness of frankfurters made with chicken. Increases in toughness or firmness were noted as the level of skin increased, and a significant difference reported above a 20% skin addition.

Use of skin in turkey products may increase total bacterial counts in the product (Frazier, 1967). Work done on the bacterial spoilage of poultry has indicated that most of the bacterial growth takes place on the surfaces, the skin, body cavity, lining, and cut surfaces, and the decomposition products diffuse slowly into the meat.

Product development utilizing turkey meat should be formulated with considerations as to consumer appeal, appearance, and acceptability (Baker et al., 1966). Two quality factors related to a product's acceptability are palatability and microbial quality. Microbial contamination and growth can cause a loss of flavor as well as health hazards. The following review is concerned with selected factors that may affect eating and microbial quality of turkey meat.

Storage of Turkey Meat

Oxidative Changes. One problem encountered in frozen storage of turkey meat is fat rancidification. Oxidation in various meats during storage may be attributed to three major factors: the degree of unsaturation of fatty acids present, heme catalysis, and content of natural antioxidants (Keskinel et al., 1964). Turkey fat is less stable than chicken and red meat fat, and has a shorter frozen storage life. The rapid autoxidation of turkey muscle has been attributed to a high percentage of unsaturated fatty acids. Scott (1958) reported that turkey fat contained 30% saturated and 70% unsaturated fatty acids. Beef tallow was reported to contain 53% saturated and 47% unsaturated fatty acids. Oxidation of the unsaturated fatty acids may contribute to rancid and stale off-flavors if present in high concentrations (Watts, 1962). Keskinel et al. (1964) compared oxidative changes in cooked light and dark turkey, beef, lamb, and pork, and reported greater oxidative changes in dark turkey meat than in other meats. Different degrees of oxidation suggested that the degree of hematin catalysis could be a factor. In that study the oxidation of light turkey meat was as high as that of the heavily pigmented beef, and was attributed to the greater unsaturated lipids of poultry than of other meats. The inferior stability of turkey fat also may be attributed to a lower content of natural antioxidant such as tocopherol (Mecchi et al., 1953).

Because of the high fat content of turkey skin, it has been incriminated as a source of off-flavor and rancidity development. May et al. (1962) in a study of the keeping quality of skin, muscle, and kidney tissue from commercially processed ready-to-cook broilers found that skin tissue spoiled first (determined by tissue off-odor and bacterial counts from like tissue) in 75% of the broilers studied; whereas, muscle tissue had the longest shelf life after storage at 39.2°F. However, Katz et al. (1966) observed that the phospholipids from turkey muscle contained more long chain fatty acids than the phospholipids from skin and depot fat, and the meat contained sufficient polyunsaturated fatty acids to be a major concern in maintaining stability of poultry meat. Hanson et al. (1959) found that flavor changes develop at a faster rate in poultry meat than in skin. Greater increases in peroxide values from the meat than the skin suggested a greater rate of flavor change in the meat itself.

The 2-thiobarbituric acid (TBA) test is an objective measurement of lipid oxidation (Tarladgis et al., 1960). TBA values (mg malonaldehyde per 1,000 g tissue) have been related to flavor deterioration in meat products. Threshold values for detection of off-flavors, odors, and rancidity in cooked meats have been reported. Mahon (1962) stated that TBA values greater than 2 indicated rancid chicken.

Temperature and Time Effects. Temperature and time of storage both have an effect upon physical and chemical changes in meat that are related to quality. Klose et al. (1950) studied the temperature of storage (0°, 10°, -10°, -30°F) for deboned and cross-cut turkey steaks, and noted greater off-flavor in steaks stored at 0° or 10°F for 3 mo than in those stored at -10°F for 12 mo. Less off-flavor was indicated for the control steaks stored at -30°F for all time periods. Klose et al. (1955) studied quality changes in ready-to-cook turkey stored (0°, 10°, -10°, -30°F) for periods up to 18 mo. Taste panel evaluation revealed small but consistent increases in rancidity; panel results were consistent with peroxide development with increases in storage temperature. Carlin et al. (1959) found that pre-cooked, frozen broilers following reheating developed an off-flavor that increased with storage time. Cash and Carlin (1968) found that TBA values increased and off-flavor developed with increased storage time of precooked frozen turkey.

Investigators have reported the effects of length and temperature of storage on lipid oxidation in cooked meat. Keskinel et al. (1964) reported a rapid accumulation of carbonyl compounds in cooked meats stored at refrigerator temperatures (4° to 6°C) as compared with meats frozen at -18°C following cooking. For turkey steaks, Conner et al. (1953) found gradual increases in peroxide values of turkey fat throughout a 14-mo storage period at -10°F.

Microbial Changes. Microbial populations survive freezing although numbers decrease slowly during storage. If a product has a high microbial population before freezing, usually it will remain in this condition after frozen storage. Freezing and thawing occasionally has caused an apparent increase in the bacterial count on frozen foods. This is attributed to the mechanical breaking up of clumps of bacteria so that the product gives a higher count (Frazier, 1967). Conner et al. (1953) studied bacterial flora of turkey steaks prepared fresh or from a bird frozen one year prior to steaking. Frozen storage of the bird had little influence on bacterial count, whereas there was considerable variation in numbers of bacteria present in individual steaks. Freezing the steaks produced a marked reduction in bacterial counts with storage up to 14 mo at -10°F.

Precooked, Reheated Turkey Meat

Eating Quality. The quality of cooked poultry is optimum immediately after cooking. If meat is not frozen, the characteristic flavor of cooked poultry is lost rapidly during short holding periods. During storage, freshly cooked poultry loses "freshly cooked" flavor and develops a "warmed over" and rancid flavor (Van Arsdel et al., 1969).

Sensory evaluation of precooked, reheated meats indicates that flavor of the freshly cooked is superior to precooked, reheated meat. Jacobson and Koehler (1970) studied flavor of cooked poultry and indicated pronounced flavor changes after short-time refrigerated and frozen storage. Sensory evaluation indicated a decline in meaty flavor with increases in rancid and stale flavors following 2 and 4 days refrigerated storage. Characteristic flavor of cooked turkey meat was not lost during 2 or 4 days frozen storage; however, TBA values increased during those storage conditions. Tims and Watts (1958) stated that TBA values increased with storage time and odor desirability decreased when cooked beef, lamb, pork, and chicken were held at refrigerator temperatures for nine days. Cipra and Bowers (1970) studied flavor and chemical changes of precooked, reheated and freshly braised turkey breasts, and reported no significant difference in TBA values between treatments; however, reheated meat generally showed higher TBA values than freshly cooked meat. Meaty-brothy aroma and flavor were more intense in freshly cooked breast pieces and stale rancid flavor more intense in braised, reheated breasts.

Carlin et al. (1959) observed that broilers precooked for 3 min prior to freezing developed more off-flavor than did broilers precooked for 10 min; untreated broilers were superior to precooked in all palatability characteristics. TBA values were always lower for fresh frozen than precooked reheated broilers. Cash and Carlin (1968) found that turkey flavor of freshly frozen roasts was more intense than those precooked, reheated and stored 3 to 11 mo.

Microbial Quality. The precooking of frozen meat entrees reduced the number of microorganisms present, but did not eradicate any type (Hussemann, 1951). Bryan et al. (1968) determined total aerobic counts on commercially prepared turkey rolls that were precooked and frozen, and reported counts ranging from less than one organism to 670 bacteria per gram. Uncooked turkey roll counts ranged from 2,500 to 860,000 per gram. Even though the cooking process reduces the number of microorganisms in the product and few organisms multiply below 15°F, precooked foods may serve as substrates for the growth of microorganisms. Care must be taken in the handling, preparation, freezing, thawing, and reheating of the precooked food.

Effect of Phosphate Salt on Meat Quality

The phosphate salts most extensively used in poultry meat are sodium tripolyphosphate and sodium hexametaphosphate. Phosphates are approved for use in the curing of meats and in cooked poultry products where the level of additive is equal to or less than 0.5% in the cooked product. Certain effects of sodium salts of phosphoric acid on meat seem well established and have been reported to enhance flavor, reduce cooking time and losses, reduce microbial growth in poultry, and increase the water-holding capacity.

Cooking Losses and Time. Swift and Ellis (1957) added phosphates to bologna emulsions, and found that cooked bologna with phosphate had less shrinkage than the untreated bologna. Schermerhorn et al. (1963) studied the effects of two polyphosphate salts in three concentrations on moisture and cooking losses of broilers, and reported lower cooking losses for the polyphosphate treated than non-treated broilers. Mahon (1962) found that chicken carcasses soaked in 3, 6, and 12% solutions of a phosphate salt for 2, 6, or 24 hr prior to stewing had lower cooking losses than carcasses soaked in water for the same time period. He suggested that the retention of more natural juices through phosphate treatment would permit more rapid heat conduction into the carcass and thereby reduce cooking time 5 to 10%.

Flavor. Polyphosphate salts assist in maintaining the freshly cooked flavor in cooked poultry (Schlamb, 1970). Spencer et al. (1963) reported that oxidative deterioration of cooked turkey meat was reduced initially after 1, 3, or 6 mo at 0°F through treatment with phosphate salts as determined by sensory and TBA values. Tims and Watts (1958) studied flavor changes and fat rancidity during cooking and storage of uncured meats. A 0.5% concentration of four types of phosphate salts held TBA values below threshold levels. Mahon (1962) found that chicken carcasses maintained 2 to 24 hr in a solution of mixed polyphosphate salts retained a fresh flavor for a longer period of time than untreated samples. Thomson (1964) reported that a mixture of polyphosphate salts was effective in inhibiting oxidative deterioration during the commercial production of frozen cooked chicken. Treated samples showed no or slight off-flavor and TBA values of approximately one; untreated samples had medium-strong off-odor and TBA values of about six.

Juiciness. Hamm (1953) considered the ability of meat to retain moisture during cooking as the most important factor affecting juiciness of meat. He cited several phosphate salts as being effective agents in increasing water-binding capacity of meat. Morse (1955) and Hamm (1960) agreed that by changing the pH or increasing the alkalinity of meats through the use of polyphosphate salts that there is an increased water-holding capacity of meat. Mullins et al. (1958) investigated the effect of sodium hexametaphosphate in the pickle injected into hams on the sensory properties of the ham. Hams injected with the phosphate were scored slightly higher for juiciness than hams that did not contain the additive; however, the difference was not statistically significant. May et al. (1963) reported that juiciness was enhanced when cut-up chicken fryers were treated with a commercial polyphosphate mixture (4, 8, or 10 oz/gal). Phosphate treatment increased panel scores for juiciness of both light and dark meat in direct proportion to the phosphate level. For light meat, the samples containing the high level (10 oz/gal) were significantly ($P < 0.01$) more juicy than those with the lower phosphate levels. There were no significant differences among phosphate levels for dark meat.

Tenderness. Carpenter et al. (1961) injected U. S. Cutter and Canner beef rounds with 10, 15, and 20% solutions of sodium hexametaphosphate to increase the original weight by 5%. Control rounds were injected with water. Sensory evaluation indicated greater tenderness for treated than for control samples. May et al. (1963), Schermerhorn et al. (1963), and Spencer et al. (1962, 1963), reported that polyphosphate salt treated chicken fryers resulted in greater panel tenderness scores than non-treated fryers; however, Schermerhorn et al. (1964) observed little influence on shear values when polyphosphate salts at the 4, 8, or 12% concentration were used to treat hen carcasses.

Microbial Quality. Spencer et al. (1962) indicated that polyphosphate salts may prove useful in altering microbial populations of poultry meat. By chilling chicken carcasses for 6 hr in ice water containins 10 oz polyphosphate per gallon of water, the rate of microbial spoilage was less for the polyphosphate treated chicken as determined by plate count, ultraviolet fluorescence, and off-odor. Steinhauer et al. (1964) found that the use of an 8% concentration of two commercial blends of polyphosphate salts in the cooling water resulted in lower average bacterial counts in treated carcasses as compared with non-treated. Polyphosphate salts did not alter the type of organisms on the carcasses held at 5°C.

EXPERIMENTAL PROCEDURE

Preparation of Roulades

Roulades were prepared from fillets of turkey breast meat and a ground meat and skin mixture according to the following procedure. Frozen turkey parts (drumsticks, wings, and necks) were obtained from a local plant. The skin and meat were removed from the parts while they were partially frozen. Equal portions of light and dark meat were ground separately with a Kenmore electric food grinder equipped with a 1/8-in plate and mixed. Frozen skin (to obtain a 20% level based on weight of meat and skin mixture) was ground once (1/8-in plate) and incorporated with the mixed ground meat in the food grinder. The ground mixture was portioned using a No. 16 household scoop (2 oz $\pm$ 1%) and shaped into 3 1/2 x 1 1/2-in portions. Meat portions were wrapped in Saran and aluminum foil and frozen at -10°F for approximately 18 hr.

Breast halves from six U. S. Grade A tom turkeys (22 to 24 lb) similar with respect to age, feeding, and processing were obtained from a local plant. Breasts were prepared for filleting while partially frozen by removing the skin and excising the breast muscles from either side of the keel bone. Each turkey breast was sliced into 24 fillets with a Toledo electric meat slicer on No. 7 setting. Fillets were trimmed to approximately 3 x 5 in. The frozen preshaped ground meat mixture was placed along the length of each fillet and the fillet rolled around the meat. Ground meat for precooked roulades was thawed for 2 hr at room temperature before rolling inside the breast fillet. For freshly cooked roulades, frozen ground meat was rolled inside breast fillets. Each roulade was secured with a wood pick, and coated with a flour and salt mixture (250 g flour; 18 g salt, Fowler et al., 1961).

Treatments

Eight treatment combinations were used to study the effect of polyphosphate salt addition, precooking, and storage time on the quality of turkey roulades. Three of the 24 roulades prepared from each of six turkeys were assigned at random to each of eight treatment combinations (Fig. 1).

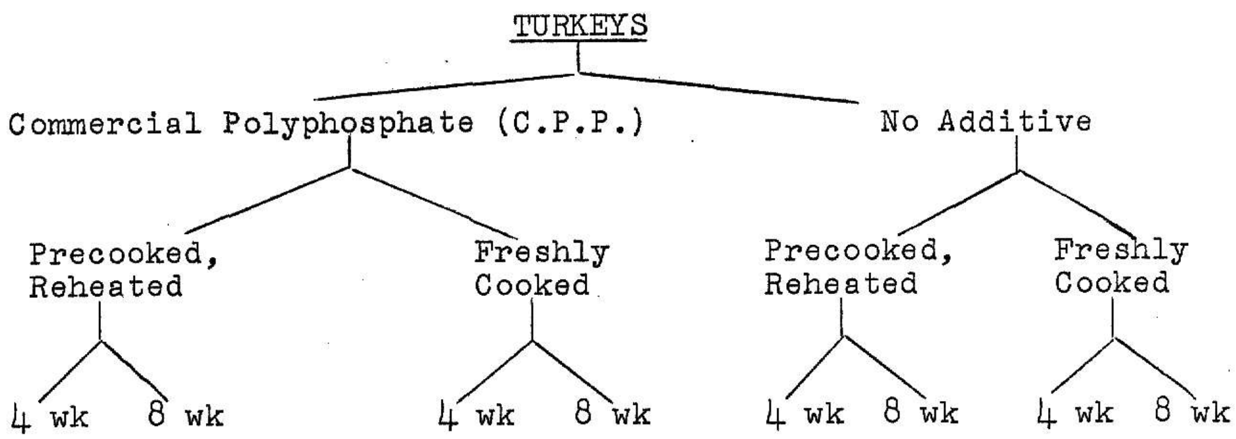

Fig. 1 - Experimental design for treatment combinations.

The commercial polyphosphate (C.P.P.) salt was added to the ground meat and skin mixture at 0.5% level based on weight of meat and skin mixture (Tims and Watts, 1958).

Precooked, reheated roulades were fried in 2 1/2 qt Wesson Oil (155°C) in a Sunbeam household electric deep-fat fryer to an internal temperature of 75°C as determined by a thermometer inserted into the center of each roulade. Roulades were drained on absorbent paper toweling, packaged in plastic bags, frozen in a Frigidaire upright household freezer, and stored at -10°F for 4 or 8 wk. Prior to evaluation, samples were thawed 1 1/2 hr at room temperature (25°C) and reheated in an Amana Radar Range to an internal temperature of 60°C.

Roulades to be freshly cooked were packaged as outlined for precooked, but were frozen raw and stored 4 or 8 wk. Those roulades were fried in deep fat (155°C) to an internal temperature of 85°C following thawing as outlined for precooked, reheated roulades. Roulades subjected to the four treatment combinations were evaluated after 4 and 8 wk frozen storage.

Sensory Evaluation

Center 3/8-in slices from two roulades per treatment were assigned to preheated covered casserole dishes (coded 1 to 4) according to a randomized plan (Table 5, Appendix). Casserole dishes were kept warm prior to evaluation on an electric food warmer at medium setting. Small plastic bags were used as liners for each casserole dish to retard moisture loss. Six panelists scored the coded samples for appearance, flavor, tenderness, juiciness, and acceptability (Form 2, Appendix) in an organoleptic analysis laboratory at individual booths. Coded roulades were judged for appearance under the MacBeth Skylight. Numbered positions for the roulades judged for appearance were identical to sample placement in heated casserole dishes.

Microbial Measurements

Total bacterial counts were made on six freshly prepared roulades (3 with C.P.P. and 3 without) and on samples from the eight treatment combinations. Microbiological methods outlined in J.A.O.A.C., (1966) were used with modifications made in the size of sample and blending technique. An 11-g sample was taken from the center portion of the roulade, frozen and blended in a sterile high-speed blender jar for 15 sec. Freshly prepared raw samples for microbiological evaluation were frozen, then plated one and two days following preparation. Cooked roulades were frozen, then plated the day following cooking or reheating.

Serial dilutions for the freshly prepared samples were 1:10 to 1:1,000,000. Dilutions for the cooked samples were 1:10 to 1:1,000. Triplicate counts were made for each serial dilution. Total bacterial count was carried out by plating on Standard Plate Count Agar. Plates were incubated 48 $\pm$ 2 hr at 35^{o}C, and plates were counted that contained 30 to 300 colonies. For plates not containing 30 to 300 colonies, a record of the dilution was made along with the number of colonies found. An average count of the triplicate plates for each serial dilution was reported as aerobic plate count per gram (A.O.A.C., 1966). Colonies from the incubated plates were counted with the aid of a 3 x 5X hand magnifier.

Chemical Measurements

End portions of roulades remaining after removal of tastepanel samples were ground in a Kenmore electric food grinder (1/8-in plate), and used to determine percentage moisture and TBA values. Duplicate 10-g samples from each treatment were dried in the Brabender Semi-Automatic Moisture Tester for 60 min at 121°C. Thiobarbituric acid values (TBA) were used to measure oxidative rancidity. TBA values were determined for duplicate ground, 10-g samples from roulades given each of the treatment combinations. The method of Tarladgis et al. (1960) was followed. Optical density readings from the Beckman Du Spectrophotometer were multiplied by 7.8 to convert to mg malonaldehyde per 1,000 g meat.

Analysis of Data

A 2 x 2 x 2 factorial arrangement of two ingredient formulations, two heating treatments, and two storage times produced data suitable for analyses of variance with the following outline:

Source of Variation		df
Additive		1
Heating treatment		1
Storage		1
Turkey		5
Panel member		5
Treatment combinations		3
Storage x additive	1	
Storage x heating treatment	1	
Additive x heating treatment	1	
Error		247
Total		263

This analysis removed turkey and panel member variations from the desired comparisons and provided ample degrees of freedom for estimation of the error variance. LSD's were calculated when F-values for treatment interactions were significant.

RESULTS AND DISCUSSION

Quality of freshly cooked and precooked, reheated roulades with and without C.P.P. stored 4 and 8 wk was evaluated by a sensory panel and by chemical and microbial measurements. Effects of those treatments are discussed. Though the analyses of data remove turkey and panel member variation and indicated significant variation among turkeys and panel members, those factors are not discussed. Data for all measurements for the six replications are presented in Tables 6 to 11, Appendix.

Eating Quality

Effect of C.P.P. All eating quality factors except appearance and tenderness were influenced by the additive (Table 1). No effect on appearance was expected because the C.P.P. salt was added to the ground meat mixture inside the breast fillet. Off-flavor and flavor desirability scores were affected significantly ($P < 0.01$) by the addition of C.P.P. Roulades with C.P.P. received lower off-flavor and higher flavor desirability scores than roulades without the additive. Those results agree with results of others who have found polyphosphate salts reduced off-flavor and maintained a freshly cooked flavor in poultry meat (Mahon, 1962; Schlamb, 1969; Thomson, 1964; Tims and Watts, 1958).

Tenderness of roulades was not affected by the addition of

Table 1 - Mean[a] eating quality scores[b] for turkey roulades

Factor	Storage (S) (wk)	Additive (A)		Heating Treatment (HT)		Significance of F-value				
		C.C.P.	None	Freshly cooked	Precooked, reheated	A	HT	S	AxHT	SxHT
Appearance	4	3.0	3.1	2.6	3.5	ns	**	**	ns	ns
	8	3.4	3.6	3.0	3.9					
Off-flavor	4	1.8	2.6	2.0	2.4	**	**	ns	ns	ns
	8	1.9	2.4	1.8	2.5					
Flavor	4	3.7	3.0	3.4	3.3	**	*	ns	ns	ns
	8	3.6	3.1	3.6	3.1					
Tenderness	4	3.8	3.6	3.6	3.7	ns	**	ns	ns	*[c]
	8	3.8	3.7	3.5	4.0					
Juiciness	4	3.8	3.4	3.6	3.6	**	ns	ns	ns	ns
	8	3.7	3.5	3.6	3.6					
Acceptability	4	3.4	2.8	3.1	3.1	**	ns	ns	**	ns
	8	3.5	3.1	3.5	3.1					

[a]Mean of 12 roulades.

[b]1 = undesirable appearance, flavor and acceptability, imperceptible off-flavor, very tough, and very dry to 5 = very desirable appearance, flavor and acceptability, very pronounced off-flavor, very tender, and very juicy.

[c]Least significant difference = 0.3.

*Significant at the 5% level.

**Significant at the 1% level.

ns = not significant.

C.P.P. salt. Reported effects of C.P.P. salts on meat tenderness conflict. Several investigators have reported increased tenderness of meat with C.P.P. treatment (Carpenter et al., 1961; May et al., 1963; Schermerhorn et al., 1963; Spencer et al., 1962, 1963), but Schermerhorn et al. (1964) found no difference in shear values for hen muscle with and without C.P.P. Roulades containing C.P.P. were significantly ($P < 0.01$) more juicy than roulades without C.P.P. Investigators have found increased juiciness scores when C.P.P. salts were used in the chilling water of cut-up chicken pieces (May et al., 1963, 1963). Moisture retention is influenced by pH (Hamm, 1953, 1960; May et al., 1963; Morse, 1955), and pH increased by C.P.P. salts. Alkaline phosphate salts increased the pH of meat from 5.3 or 5.5 to 7.0 or 7.4 and enabled meat proteins to take up and hold water. Decreased off-flavor, increased flavor desirability and juiciness of the C.P.P. treated roulades resulted in significantly ($P < 0.01$) higher acceptability scores for those samples than for roulades without the additive. A significant interaction was found for additive and heating treatment effects on acceptability scores (Tables 1 and 2). For freshly cooked roulades, no difference was found between those with or without C.P.P.; but for precooked, reheated roulades, those with C.P.P. were more acceptable than those without C.P.P. Those results indicate that C.P.P. salts were more effective when used for cooked than for raw meat.

Effect of Heating Treatment. Heating treatment significantly influenced appearance, off-flavor, flavor desirability, and tenderness (Table 1). Precooked, reheated roulades had a more ($P < 0.01$) desirable appearance than those freshly cooked. No effort was made to use cooking methods that produced equally browned products. Precooked, reheated roulades were fried to 75°C in deep fat, and reheated to 60°C in a microwave oven; freshly cooked roulades were fried to 85°C in deep fat. This may explain, in part, why the reheated roulades were judged a more desirable brown than the freshly cooked ones which were a dark brown color. Precooked, reheated roulades had higher ($P < 0.01$) off-flavor and lower ($P < 0.05$) flavor desirability scores than freshly cooked roulades. Those results agree with reports of others who found a more "characteristic" fresh flavor for freshly cooked and a decline in fresh flavor with an increase in stale or rancid flavor for precooked, reheated poultry (Cash and Carlin, 1968; Cipra and Bowers, 1970; Jacobson and Koehler, 1970).

Table 2 - Mean[a] acceptability scores for freshly cooked and precooked, reheated roulades with and without C.P.P.

Heating Treatment	Additive	
	C.P.P.	None
Freshly cooked	3.4	3.2
Precooked, reheated	3.5	2.7

[a]24 roulades; least significant difference = 0.3.

Precooked, reheated roulades were more tender ($P < 0.01$) than freshly cooked roulades. Differences in tenderness between heating treatments may be attributed to the fact that freshly cooked roulades, fried to 85°C, tended to become more crisp and dehydrated during cooking than roulades precooked to 75°C and reheated to 60°C. A significant ($P < 0.05$) interaction between storage and heating treatment effects on tenderness scores was found (Table 1). For roulades stored 8 wk, freshly cooked ones were less tender than precooked, reheated roulades. For those stored 4 wk, no difference was found in tenderness. A significant ($P < 0.01$) interaction between additive and heating treatment effects was found for acceptability (Tables 1 and 2). For roulades containing C.P.P. there was no difference in acceptability for freshly cooked and precooked, reheated; but for roulades without C.P.P., reheated samples were more undesirable from the standpoint of acceptability than freshly cooked ones. This finding can be explained by a greater lipid oxidation that would occur during precooking and reheating of those samples and reduced lipid oxidation for the C.P.P. treated samples (Mahon, 1962; Tims and Watts, 1958).

Effect of Storage Time. Generally, eating quality was not affected by storage, but appearance was affected (Table 1). Storage time significantly affected ($P < 0.01$) appearance. Roulades stored 8 wk received higher scores for appearance than those stored 4 wk. Panelist's increased familiarity with samples after 8 wk may be a factor that could explain, in part, those findings. A significant ($P < 0.05$) interaction for storage and heating treatment effects on tenderness was found. Precooked, reheated roulades stored 8 wk were more tender than those stored 4 wk (Table 1); however, for freshly cooked roulades there was no difference in tenderness between those stored 4 and 8 wk. No reason can be offered to explain those storage effects. Eating quality of turkey meat has been reported to decrease with increased storage time (Conner et al., 1953; Klose et al., 1950). Decreases in quality with increased storage time were not observed in this study as the storage periods were short.

Moisture and TBA. Means for percentage moisture and TBA values for roulades are shown in Table 3. Analyses of variance indicated that moisture content was affected significantly by the additive ($P < 0.05$) and heating treatment ($P < 0.01$), but was not affected by length of storage. Roulades with C.P.P. had significantly more moisture than roulades without C.P.P. Other investigators have reported increased water-holding capacity as a result of polyphosphate salt treatment (Hamm, 1953, 1960; Morse, 1955). The difference in moisture did not influence panel juiciness scores; panelists noted no difference in juiciness between C.P.P. treated and nontreated samples. Precooked, reheated roulades contained more moisture than the freshly cooked ones. Heating treatment for freshly cooked roulades may have influenced moisture content, as those roulades may have lost more moisture with frying to 85°C than roulades precooked to 75°C and reheated to 60°C.

TBA values measured the extent of oxidation of the roulades (Table 3). Additive, heating treatment, and storage time all

Table 3 - Moisture percentages, TBA values, and microbial counts for freshly cooked and precooked reheated roulades with and without additive[a]

Measurement	Storage (S) (wk)	Additive (A)		Heating Treatment (HT)		Significance of F-value				
		C.P.P.	None	Freshly cooked	Precooked, reheated	A	HT	S	AxHT	SxHT
Moisture	4	49.8	47.2	43.4	53.6	*	**	ns	ns	ns
	8	50.2	49.0	44.0	55.2					
TBA value[b]	4	0.303	0.515	0.217	0.602	**	**	*	*[c]	ns
	8	0.218	0.439	0.157	0.501					
Microbial Counts										
10^{-1} Dilution	4	1,439	1,263	1,408	1,295	ns	ns	**	ns	ns
	8	3,205	2,835	2,643	3,397					
10^{-2} Dilution	4	6,075	5,400	7,492	3,983	ns	ns	ns	ns	ns
	8	7,142	8,825	5,225	10,742					
10^{-3} Dilution	4	28,333	12,000	34,500	5,833	ns	ns	ns	ns	ns
	8	10,083	30,833	6,167	34,750					

[a]Mean of 12 roulades.

[b]mg Malonaldehyde/1,000 g tissue.

[c]Least significant difference = 0.2.

* Significant at the 5% level.
** Significant at the 1% level.
ns = not significant.

affected the TBA values. Roulades with C.P.P. had lower ($P < 0.01$) TBA values than those prepared without C.P.P. A significant interaction was found for heating treatment and additive effects (Tables 3 and 4). For freshly cooked roulades, TBA values for roulades with and without C.P.P. were similar. For precooked, reheated samples, those with C.P.P. had lower ($P < 0.05$) TBA values than those without. Reduced TBA values have been reported for cooked meats and poultry with the use of C.P.P. salts as dips or cover solutions (Mahon, 1962; Thomson, 1964; Tims and Watts, 1958); those reports are in agreement with results from this study. TBA values for freshly cooked roulades were lower ($P < 0.01$) than precooked, reheated ones. Higher TBA for precooked, reheated roulades than for freshly cooked may be attributed to greater lipid oxidation during storage of cooked muscle. Those reports agree with reports cited earlier (Cash and Carlin, 1968; Cipra and Bowers, 1970; Jacobson and Koehler, 1970).

Generally, roulades stored 8 wk had lower ($P < 0.01$) TBA values than roulades stored 4 wk. Since oxidation of fatty acids tends to increase rather than decrease with increased storage time, it is difficult to explain those findings. TBA values for frozen precooked turkey roasts stored 9 mo increased as storage time increased up to 9 mo (Cash and Carlin, 1968). The fact that increased TBA values were not noted for roulades stored 8 wk may indicate that the storage periods used in this study were too short to produce that effect.

Table 4 - Mean[a] TBA values for freshly cooked and precooked, reheated roulades with and without additive

Heating Treatment	Additive	
	C.P.P.	None
Freshly cooked	0.120	0.253
Precooked, reheated	0.400	0.712

[a]24 roulades, least significant difference = 0.2.

Microbial Measurement. Total microbial counts were determined by culturing on Standard Plate Agar under aerobic conditions. The average count for raw, freshly prepared roulades was: serial dilution 10^{-1}, 7,000 bacteria/g; and serial dilution 10^{-5}, 0 bacteria/g. Bacterial counts for raw samples with and without additive were within the same bacterial population range (Harris, 1971). No significant effects for addition, heating treatment, or storage were noted on total bacterial counts, except for a storage effect on the 10^{-1} serial dilution (Table 3). Statistically, bacterial counts for roulades were higher ($P < 0.01$) after 8 wk storage than after 4 wk for that dilution; but when considering bacterial population ranges (Harris, 1971) those counts are similar. Bacterial counts were not reduced during storage periods studied, and may be explained by the fact that reduction in bacterial counts, according to Frazier (1967), is a gradual process; perhaps storage periods studied were not adequate in length to produce that effect. Total bacterial counts for raw and cooked turkey roulades indicated that microbial quality was not affected by handling, freezing, and thawing. Generally, total plate counts of one million bacteria per gram indicate spoilage and health hazards (Frazier, 1967; Harris, 1971).

SUMMARY

The effects of two ingredient formulations, two heating treatments, and two storage periods on the eating and microbial quality of turkey roulades were investigated. Eating quality factors influenced by the addition of C.P.P. were off-flavor, flavor desirability, juiciness, and acceptability; appearance and tenderness were not affected. Roulades prepared with C.P.P. salt had significantly higher ($P < 0.01$) flavor desirability, juiciness, and acceptability, and lower ($P < 0.01$) off-flavor than those without the additive. Precooked, reheated roulades were more desirable ($P < 0.01$) in appearance and more tender ($P < 0.01$), but received higher ($P < 0.01$) off-flavor and lower ($P < 0.05$) flavor desirability scores than freshly cooked samples. Precooked, reheated roulades without C.P.P. salt were more undesirable from the standpoint of acceptability than freshly cooked samples; no difference in acceptability was found between freshly cooked and precooked, reheated roulades prepared with C.P.P. Generally, eating quality was not affected by storage.

Percentage moisture for precooked, reheated roulades ($P < 0.01$), and those with C.P.P. ($P < 0.05$) was higher than for freshly cooked roulades and those without C.P.P. Freshly cooked roulades had lower ($P < 0.01$) TBA values than precooked,

reheated roulades. Freshly cooked roulades with and without C.P.P. had similar TBA values, but precooked, reheated roulades with C.P.P. had lower ($P < 0.05$) TBA values than those without C.P.P. Generally, treatments did not affect total bacterial counts.

In general, eating quality was improved by the addition of C.P.P. salt, decreased by precooking and reheating, and not affected by the storage periods used in this study.

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APPENDIX

List of abbreviations and terms used for appendix tables:

C.P.P. = Commercial polyphosphate, precooked, reheated

N.F. = No additive, freshly cooked

C.P.F. = Commercial polyphosphate, freshly cooked

N.P. = No additive, precooked, reheated

HT = Heating treatment

S = Storage for 4 and 8 weeks

A = Commercial polyphosphate salt additive

** = Significant at the 1% level

* = Significant at the 5% level

Eating Quality Scores:

1 = undesirable appearance, flavor, and acceptability, imperceptible off-flavor, very tough, and very dry, 5 = very desirable appearance, flavor, and acceptability, very pronounced off-flavor, very tender, and very juicy.

Form 1 - Scorecard for Turkey Roulades

Judge ____________
Date ____________

Sample No.	Appearance	Flavor		Tenderness	Juiciness	Acceptability
		Off-Flavor	Desirability			
1						
2						
3						
4						

Appearance

5 Very desirable
4 Desirable
3 Slightly desirable
2 Slightly undesirable
1 Undesirable

Off-Flavor

5 Very pronounced
4 Pronounced
3 Slightly pronounced
2 Slightly perceptible
1 Imperceptible

Flavor desirability

5 Very desirable
4 Desirable
3 Acceptable
2 Slightly undesirable
1 Undesirable

Tenderness

5 Very tender
4 Tender
3 Slightly tender
2 Slightly tough
1 Very tough

Juiciness

5 Very juicy
4 Juicy
3 Slightly juicy
2 Slightly dry
1 Very dry

Acceptability

5 Very desirable
4 Desirable
3 Acceptable
2 Slightly undesirable
1 Undesirable

Table 5 - Order of sample presentation to taste panel[a]

Turkey No.	Evaluation Period	Storage (S) (wks)	Order			
			1	2	3	4
I	1	4	N.F.	C.P.P.	N.P.	C.P.F.
II	2		N.P.	N.F.	C.P.P.	C.P.F.
III	3		N.P.	C.P.P.	C.P.F.	N.F.
IV	4		C.P.F.	N.F.	C.P.P.	N.P.
V	5		C.P.F.	C.P.P.	N.P.	N.F.
VI	6		C.P.P.	C.P.F.	N.F.	N.P.
I	7	8	C.P.P.	N.F.	N.P.	C.P.P.
II	8		N.F.	N.P.	C.P.F.	C.P.P.
III	9		C.P.F.	N.P.	N.F.	C.P.P.
IV	10		C.P.P.	N.F.	C.P.F.	N.P.
V	11		N.F.	C.P.F.	N.P.	C.P.P.
VI	12		C.P.F.	N.P.	C.P.P.	N.F.

[a]See p. 34 for explanation of abbreviations and terms.

Table 6 - Scores for appearance and off-flavor of freshly cooked and precooked, reheated roulades with and without additive[a]

Turkey No.	Storage (S) (wk)	Appearance C.P.F.	Appearance N.P.	Appearance C.P.P.	Appearance N.F.	Off-Flavor C.P.F.	Off-Flavor N.P.	Off-Flavor C.P.P.	Off-Flavor N.F.
I	4	2.0	3.0	2.5	2.0	1.2	2.2	1.3	0.8
II		2.0	3.7	3.2	2.2	1.8	2.3	1.2	2.2
III		2.2	3.7	3.7	2.2	1.3	2.5	1.8	1.3
IV		2.3	3.7	3.2	2.3	1.2	2.3	2.7	2.2
V		2.8	2.5	2.7	3.2	1.7	3.7	1.0	3.8
VI		3.3	3.5	3.8	2.8	1.7	3.3	3.0	2.7
I	8	3.0	3.0	3.3	3.0	2.2	1.5	2.0	1.3
II		2.5	3.7	3.8	2.5	1.3	2.0	1.7	2.2
III		2.7	3.8	3.3	2.3	1.5	2.8	1.8	1.3
IV		2.0	4.2	4.0	2.8	1.5	4.0	2.0	2.2
V		2.5	4.7	3.7	3.0	1.0	3.0	1.7	1.2
VI		3.3	3.8	3.0	3.3	2.0	3.0	1.8	1.8
Mean		2.8	3.8	3.6	2.8	1.7	2.9	2.0	2.1

Analysis of Variance:

Source of Variation	df	F-Value Appearance	F-Value Off-Flavor
Turkey	5	2.99*	3.22**
Storage (S)	1	13.29**	0.31
Heating Treatment (HT)	1	74.48**	19.79**
Additive (A)	1	1.84	26.63**
Panel	5	43.13**	7.09*
S x HT	1	0.13	1.27
S x A	1	0.25	1.02
HT x A	1	0.25	3.38

[a]See p. 34 for explanation of abbreviations and terms.

Table 7 - Scores for flavor desirability and tenderness of freshly cooked and precooked, reheated roulades with and without additive[a]

Turkey	Storage (S)	Flavor				Tenderness			
No.	(wk)	C.P.F.	N.P.	C.P.P.	N.F.	C.P.F.	N.P.	C.P.P.	N.F.
I	4	2.7	2.3	3.2	3.5	3.0	3.0	3.7	3.5
II		3.5	3.3	3.8	2.8	3.3	3.3	3.8	3.8
III		3.2	2.0	3.2	2.8	3.2	2.7	3.0	2.7
IV		3.2	2.3	2.2	2.3	2.7	3.3	3.3	2.7
V		3.7	3.3	4.5	1.8	3.8	3.5	3.5	3.7
VI		4.7	2.7	3.0	3.2	3.8	3.5	3.8	3.0
I	8	2.8	3.0	2.8	3.0	3.5	3.3	3.5	3.7
II		4.0	3.5	3.8	3.5	3.2	3.7	4.3	3.3
III		3.2	1.8	3.0	3.3	2.7	3.8	3.8	2.7
IV		4.0	1.7	3.7	3.3	3.7	3.8	4.0	3.2
V		3.5	2.0	2.7	3.0	3.3	3.0	3.7	3.2
VI		2.7	2.7	3.3	3.8	3.0	3.8	3.8	3.2
Mean		3.7	2.8	3.6	3.3	3.6	3.7	4.0	3.5

Analysis of Variance:

Source of Variation	df	F-value: Flavor	F-value: Tenderness
Turkey	5	1.22	1.94
Storage (S)	1	0.01	0.70
Heating Treatment (HT)	1	6.30*	11.78**
Additive (A)	1	19.55**	3.64
Panel	5	10.51**	31.92**
S x HT	1	3.66	4.89*
S x A	1	0.92	0.05
HT x A	1	2.80	1.68

[a]See p. 34 for explanation of abbreviations and terms.

Table 8 - Scores for juiciness and acceptability of freshly cooked and precooked, reheated roulades with and without additive[a]

Turkey No.	Storage (S) (wk)	Juiciness C.P.F.	Juiciness N.P.	Juiciness C.P.P.	Juiciness N.F.	Acceptability C.P.F.	Acceptability N.P.	Acceptability C.P.P.	Acceptability N.F.
I	4	2.8	2.8	3.2	3.5	2.3	2.2	2.8	3.0
II		3.3	3.3	3.8	3.5	2.7	3.5	3.8	2.7
III		3.0	2.5	3.0	2.8	3.3	1.8	3.0	2.5
IV		2.8	3.0	2.8	2.7	2.3	2.3	1.8	2.3
V		3.7	3.7	4.3	3.0	3.5	3.0	3.7	2.2
VI		4.2	2.5	3.8	3.3	3.8	2.3	3.2	2.7
I	8	2.8	3.3	3.3	3.0	2.8	3.0	3.0	2.8
II		3.5	3.5	4.0	3.7	3.7	3.5	4.2	3.3
III		3.2	2.7	3.2	3.0	3.0	1.7	3.2	3.0
IV		3.5	3.0	3.2	4.0	3.8	1.8	3.5	3.8
V		3.5	2.5	3.2	2.8	3.0	1.7	3.2	3.2
VI		3.5	3.8	3.8	3.5	2.7	2.8	3.0	3.7
Mean		3.7	3.3	3.8	3.5	3.4	2.7	3.5	3.2

Analysis of Variance:

Source of Variation	df	F-value Juiciness	F-value Acceptability
Turkey	5	0.48	1.24
Storage (S)	1	0.03	2.92
Heating treatment (HT)	1	0.01	2.55
Additive (A)	1	9.35**	16.21**
Panel	5	33.06**	15.90**
S x HT	1	0.03	2.98
S x A	1	1.66	0.20
HT x A	1	3.14	6.87**

[a]See p. 34 for explanation of abbreviations and terms.

Table 9 - Moisture percentages for freshly cooked and precooked, reheated roulades with and without additive[a]

Turkey No.	Storage (S) (wk)	Treatment C.P.F.	N.P.	C.P.P.	N.F.
I	4	34.7	52.2	58.0	34.0
II		37.3	51.8	51.3	41.8
III		49.1	53.5	54.8	44.9
IV		51.0	53.9	55.6	44.7
V		45.1	51.0	53.1	40.7
VI		52.2	53.1	55.4	44.7
Mean		44.9	52.6	54.7	41.8
I	8	42.8	55.8	56.5	40.6
II		44.7	54.6	55.7	44.6
III		44.4	52.4	56.7	44.6
IV		44.2	54.1	56.5	44.2
V		44.3	53.0	56.1	44.8
VI		44.1	54.7	55.8	44.2
Mean		44.1	54.1	56.3	43.8

Analysis of Variance:

Source of Vatiation	df	F-value
Turkey	5	2.20
Storage (S)	1	1.52
Heating treatment (HT)	1	154.99**
Additive (A)	1	4.83*
S x HT	1	0.28
S x A	1	0.66
HT x A	1	0.07
S x HT x A	1	0.69

[a]See p. 34 for explanation of abbreviations and terms.

Table 10 - TBA values[a] for roulade treatment combinations[b]

Turkey No.	Storage (S) (wk)	Treatment C.P.F.	N.F.	C.P.P.	N.P.
I	4	0.117	0.456	0.269	0.909
II		0.179	0.238	0.230	0.651
III		0.031	0.293	0.484	0.800
IV		0.049	0.390	0.468	0.764
V		0.113	0.215	0.550	0.679
VI		0.289	0.230	0.811	0.562
Mean		0.130	0.303	0.476	0.727
I	8	0.137	0.238	0.203	0.616
II		0.125	0.215	0.281	0.566
III		0.090	0.117	0.374	0.605
IV		0.121	0.156	0.335	0.698
V		0.082	0.215	0.429	0.593
VI		0.113	0.274	0.332	0.979
Mean		0.111	0.202	0.326	0.676

Analysis of Variance:

Source of Variation	df	F-value
Turkey	5	1.17
Storage (S)	1	5.87*
Heating treatment (HT)	1	120.96**
Additive (A)	1	42.75**
S x HT	1	0.38
S x A	1	0.01
HT x A	1	6.46*
S x HT x A	1	1.88

[a]Expressed as mg malonaldehyde/1,000 g tissue.

[b]See p. 34 for explanation of abbreviations and terms.

Table 11 - Plate count means for storage time and heating treatment of cooked roulades prepared with and without additive[a]

Serial Dilution	Storage (S) (wk)	Treatment C.P.F.	N.F.	C.P.P.	N.P.
10^{-1}	4	1,347	1,468	1,531	1,058
	8	2,923	2,363	3,487	3,307
10^{-2}	4	6,417	8,567	5,733	2,233
	8	6,617	3,833	7,667	13,817
10^{-3}	4	47,167	21,833	9,500	2,167
	8	7,333	5,000	12,833	56,667

Analysis of variance:

Source of Variation	df	F-value for serial dilution 10^{-1}	10^{-2}	10^{-3}
Turkey	5	1.38	0.73	0.86
Storage (S)	1	23.28**	0.90	0.00
Heating treatment (HT)	1	0.85	0.18	0.00
Additive (A)	1	0.62	0.05	0.12
S x HT	1	1.57	0.05	0.12
S x A	1	0.08	0.25	1.14
HT x A	1	0.02	0.12	0.85
S x HT x A	1	0.50	2.38	0.17

[a]See p. 34 for explanation of abbreviations and terms.

EFFECTS OF A POLYPHOSPHATE SALT ON EATING AND MICROBIAL QUALITY OF PRECOOKED AND FRESHLY COOKED TURKEY ROULADES STORED 4 AND 8 WEEKS

by

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The development of a convenience meat item, turkey roulades, utilizing turkey muscle and skin was studied. The effects of two ingredient formulations, two heating treatments, and two storage periods on the eating and microbial quality of turkey roulades was investigated. A sensory panel evaluated eating quality factors: appearance, off-flavor, flavor desirability, tenderness, juiciness, and acceptability for precooked, reheated and freshly cooked roulades with and without commercial polyphosphate (C.P.P.) salt stored 4 and 8 wk. Percentage moisture, TBA values, and total microbial counts for the eight treatment combinations were determined.

Roulades containing C.P.P. salt had significantly higher ($P < 0.01$) flavor desirability, juiciness, and acceptability, and lower ($P < 0.01$) off-flavor than those prepared without the additive. Precooked, reheated roulades were more desirable ($P < 0.01$) in appearance, and more tender ($P < 0.01$), but received higher ($P < 0.01$) off-flavor and lower ($P < 0.05$) flavor desirability scores than freshly cooked samples. Precooked, reheated roulades without C.P.P. salt were less acceptable than freshly cooked samples; no difference in acceptability was found between freshly cooked and precooked, reheated roulades prepared with C.P.P. Generally, eating quality was not affected by storage.

Percentage moisture for precooked, reheated roulades ($P < 0.01$) and those with C.P.P. ($P < 0.05$) was higher than for freshly cooked roulades and those without C.P.P. Freshly cooked

roulades had lower ($P < 0.01$) TBA values than precooked, reheated roulades. Freshly cooked roulades with and without C.P.P. salt had similar TBA values; but precooked, reheated roulades with C.P.P. had lower ($P < 0.05$) TBA values than those without C.P.P. Generally, treatments did not affect total bacterial counts.

In general, eating quality was improved by the addition of C.P.P. salt, decreased by precooking and reheating, and not affected by the storage periods used in this study.