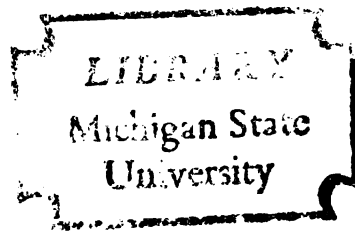


SMOKE FLAVORED CHICKEN ROLLS

Thesis for the Degree of M. S.
MICHIGAN STATE UNIVERSITY
EDWARD WALTER BRECLAW
1969

THESIS



ABSTRACT

SMOKE FLAVORED CHICKEN ROLLS

By

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Shifts in consumption and changes in egg production technology have greatly decreased the amount of fowl meat sold as ready-to-cook poultry. Since the supply of fowl meat is a by-product of egg production, the total number of these birds available for consumption has decreased only slightly in the last ten years. The results have been a continual weakening of the prices paid for this raw product to the producer, and a rise in the difficulty of marketing fowl meat for the processor.

Boned Leghorn fowl meat was obtained from a single flock to minimize product variation. The dark and light pieces of meat were combined with other ingredients and placed in elastic stockinette to make 42 light and 42 dark two lb chicken meat rolls. Six different smoke flavor treatments were applied to six rolls of light and six of dark meat, with six samples as controls for each. The smoke flavor treatments were designed to produce mild, smoke flavored products and included: soaking in a liquid smoke brine, dipping in a concentrated liquid smoke, regular

smokehouse, oil base smoke, oil base and cure smoke, dry smoke and control. The rolls were stored unfrozen for 1, 7 and 14 days and frozen for 21, 28 and 35 days after processing.

The dark and light meat rolls were evaluated separately by objective and subjective analyses. These evaluations included total bacteria counts, moisture analyses, cooking yields, peroxide values, Kramer Shear Press values, binding properties, and panel acceptability. The data were statistically analyzed and correlated.

The light meat contained more moisture, on the average, than the dark meat, and the uncured samples significantly more than the cured. Comparatively good cooking yields were obtained with the light meat having higher yields than the dark meat. Even though the peroxide values generally increased during storage, there was little evidence that any detectable level of oxidative rancidity was present. The Kramer Shear test indicated that light meat was more tender than dark meat, and the uncured meat more tender than the cured. No significant difference in tenderness was found between the products which had been frozen and those unfrozen.

Both the light and dark meat rolls exhibited good binding qualities, but the light meat was superior to the dark meat. Significant differences were obtained by the taste panel between: panel members, treatments, type of

meat and quality characteristics. No significant differences were caused by storage conditions. Juiciness of dark meat received the highest average rating of the four quality characteristics and tenderness was highest for light meat. The light meat received a higher average overall desirability rating than did the dark meat.

The chicken rolls which received the oil base, smoke-house and oil base and cure treatments were rated higher in overall desirability by the panels than were the products treated by soaking, dipping and dry smoking. Furthermore, the light meat samples rated higher in overall desirability, on the average, than did the dark meat samples from the same smoke flavor treatment.

SMOKE FLAVORED CHICKEN ROLLS

By

Edward Walter Breclaw

A THESIS

Submitted to
Michigan State University
in partial fulfillment of the requirements
for the degree of

MASTER OF SCIENCE

Department of Food Science

1969

ACKNOWLEDGMENTS

I wish to express my appreciation to Dr. L. E. Dawson for his guidance, sincere encouragement, and thoughtful criticism throughout my graduate program and preparation of this dissertation.

I would also like to thank Professor L. J. Bratzler and Dr. B. J. LaLonde for their critical review of the manuscript.

A special thanks is also expressed to Dr. B. S. Schweigert and the faculty members of the Department of Food Science at Michigan State University for the interest shown and facilities provided me. For her suggestions throughout the preparation time and especially for typing assistance, Mrs. M. Ritchey is gratefully acknowledged.

I am, in addition, indebted to the Institute of Food Technologists and the Pillsbury Company for their sponsorship of a graduate fellowship and for the funds provided by the traineeship program of the United States Public Health Service.

I also pay special tribute to my wife, Linda, whose assistance, encouragement, patience and understanding made possible the completion of this work.

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INTRODUCTION

Due to a shift in consumer demand and a change in egg production technology, the amount of fowl meat sold in the United States as ready-to-cook chicken has declined from approximately 60% of the total poultry meat consumed in 1948 to only 9% in 1968. In this same period the per capita consumption of poultry meat increased from 21.4 to 44.4 pounds per person. This dramatic change in the relative consumption of ready-to-cook fowl meat can be attributed to the growth of the broiler industry and increased acceptance of broilers, with a small total increase in turkey sales. Since the supply of fowl meat is a by-product of egg production, the total number of these birds available for consumption has decreased less than 2% in the last ten years. Therefore, the result has been a continual weakening in the prices paid for this raw product to the producer and a rise in the difficulty of marketing this fowl meat for the processor. The low salvage value of the replaced laying flock has also increased the cost of producing eggs, and the prices paid by consumers.

One of the trends today in food merchandising is to provide the consumer with more and better convenient ready-to-serve food items to meet the increasing demand for this

type of product. The reasons for this shift are numerous and often interrelated, but it will only be possible to identify the change rather than probe into the reasons for it here. Those concerned with marketing these light-weight type fowl must be aware of these changes in consumer demand and must adjust their products to better serve these wants and needs. Several studies have indicated the only real hope for obtaining higher prices for this raw product in the near future, thus raising the salvage value of the birds, is through the development of new marketable forms for this chicken meat. One possible approach, investigated in this study, was a further processed smoke flavored chicken roll. Although this kind of product might not have broad market acceptance, as a specialty item it could possibly serve the needs of certain select market segments.

The purpose of this study was to develop and evaluate a number of smoke flavored chicken products made from Leghorn fowl meat. The smoke flavored chicken rolls analyzed were designed as a result of information obtained from food industry personnel, previous studies, and preliminary testing of sensory and physical measurements of acceptable quality. By adjusting the ingredients, processing techniques, cooking and storage conditions, some of the basic food quality problems associated with the utilization of Leghorn fowl meat were studied. The final product was analyzed by taste panel judges as well as by objective methods for determining the potential consumer acceptability of the product.

LITERATURE REVIEW

Consumer demand for fowl meat, available as stewing chickens, has steadily declined. This decline has been partly attributed to the popularity of convenience foods and substitute products (Marshall 1962), as well as the growth of the broiler enterprise which has increased from 14% in 1940 to 89% in 1968 of the poultry meat consumption (Anon. 1968). Consumption of light-type fowl has subsequently declined from 12.8 lbs per person in 1948 to 3.4 lbs in 1964 and has since increased slightly to 4.0 lbs in 1968 (Anon. 1968). The consumption of all poultry meat has increased approximately one lb per person per year in this same period (Enochian and Rollag 1966).

Changes in egg production technology have increased the efficiency of egg production, paralleled by a reduction in the average size of the laying hen. This reduction in hen size has further hindered efficient processing of fowl meat, resulting in lower farm prices. Depreciation in value of the laying birds now represents the second largest cost item in producing eggs or about 8 cents a dozen (Baker et al. 1966). As a result, farm prices received per lb have declined from 25 cents in 1951 to about 8 or 9 cents in 1965,

and in some regions, such as California, to a low of 2 to 3 cents (Enochian and Rollag 1966).

Most fowl meat is basically a by-product of commercial egg production operations, hence the long term supply is essentially independent of price. Should demand increase, price would be strengthened, but the demand for fowl is greatly influenced by the price of eggs, red meats and especially broilers and turkeys (Enochian and Rollag 1966). Therefore, if the price of fowl was to increase relative to other products, consumers would begin shifting their purchases to other products causing the price of fowl to go down. Possible solutions to this difficult problem would be to develop markets, such as foreign, or alter the product to fill a consumer need now unsatisfied (Marshall 1962). Further processing of poultry fowl has been the subject of many investigations designed to provide new methods of marketing fowl. Baker et al. (1966) listed 15 new products utilizing stewing chicken meat that had been developed at Cornell University, including chicken hash, chicken sticks, chicken franks, chickalona, and chicken bologna.

Mountney (1966) reported that the factors contributing to the rapid development of further processed poultry products were: (1) surplus of poultry meat; (2) low price; (3) development of boning machines; (4) improvements in processing, storage and marketing; and (5) increased demand for convenient heat-and-serve food items. However, the major problems facing further usage of fowl meat are the

slow laborious operations of deboning, resulting in high labor costs (Kebede 1968), lower quality of birds, and generally less tender meat. Nevertheless, Hanson (1950) reported that less tender fowl meat could be successfully utilized in pre-cooked frozen food for a more flavorful product than obtained from younger birds.

Utilization of Fowl Meat in Chicken Rolls

Selection of a product which would both increase the utilization of fowl meat and attract market potential should meet the following criteria (Baker et al. 1966): (1) contain a substantial portion of fowl meat; (2) suitable for commercial production and distribution; (3) convenient for the housewife; and (4) have a sizable market potential. Boneless rolled chicken meat could possibly meet most of these requirements. Furthermore, Enochian and Rollag (1966) examined poultry products in the San Francisco Bay area and reported:

In the sandwich or luncheon meat line there were products resembling bologna containing ground-up chicken, but a sliced chicken product made from fowl was not available. This product would seem to satisfy a want that has hitherto been neglected.

The method of preparing a standard turkey roll was described by Aref (1966) and includes skinning, boning and trimming of the turkey carcasses; assembling and stuffing or tying the boneless pieces of meat after addition of seasonings and binders, then cooking, cooling and freezing. The advantages of rolled turkey reported by Evans (1950) were:

(1) low cost per serving unit; (2) complete utilization of the meat purchases; (3) less labor required to prepare the meat for serving; (4) greater flavor retention in the product; (5) less storage and freezer space required; (6) lower transportation cost per pound of edible meat; (7) lower cooking shrinkage; and (8) less loss in food nutrients during cooking.

Information about turkey rolls has been reported quite extensively but rolls made from chicken meat, and particularly from fowl meat, have received less attention. One possible explanation for this lack of reported research is the problem of tenderness. Marshall (1963) reported that smoked meat from light and heavy fowl, broilers and fryers, was generally satisfactory except that the fowl meat was less tender. Wells and Dawson (1966) found that tenderness of muscle decreased with the age of the bird and in beef, tenderness has been described as the single most important item in consumer acceptability (Pearson 1963). This could be a very limiting factor in utilization if the rolls were perceived by the consumer as not being tender.

The ability of muscle protein to hold water is a major factor in tenderness (Deatherage 1963) and the manipulation of such variables as heating, curing, dehydration and kinds of ions, would have the potential for affecting the water holding capacity of muscle protein, and thus tenderness. Influencing and improving the water-binding capacity of the meat could result in a more tender product.

The Binding Properties

Aref (1966) suggested that much abuse had been given to the proper binding of turkey rolls by the use of gelatin, which causes a slimy appearance and the disintegration of the rolls upon heating. To obtain a desirable roll the pieces of meat must touch each other while the binder is working, and the binder must produce and retain its binding effect on heating, and must withstand freezing and dehydration several times. Aref (1966) made the following analysis of binders tested: (1) gums--all found to be unsuitable; (2) egg whites--good binding when hot, crusty white seam between pieces in cold meat; (3) alginates--unsatisfactory; (4) enzymes--showed promise but not for commercial production; (5) "vital" wheat gluten--suitable; (6) NFDM solids and soy protein substances--both unacceptable; and finally (7) the best binding was obtained when the "bone side of meat was worked" with a meat mallet to tenderize, and then the worked sides were placed together before cooking.

Another aspect of binding involves the ability of the binder to hold water. Deatherage (1963) found that the water-holding capacity of red meat protein was directly related to shrinkage on cooking, drip on freezing and thawing, and tenderness. Kebede (1968) provided similar information which essentially indicated that binder material, in various poultry sausage combinations, reduced the moisture loss and thus produced higher yields. Guidelines provided

by the Meat Inspection Division of the USDA (1960) limit the use of binding materials collectively to 3.5% of the finished product. Winkler (1939) reported that the water holding capacity of muscle fibers is related to the changes in pH, i.e., muscle fibers absorb more water at pH 7.0 than at pH 6.0, and a much lower volume of water is absorbed at pH 5.0 or lower. However, Hamm et al. (1960) gave a somewhat conflicting report, stating that muscle did not lose its ability to hold water at pH values less than or equal to a pH of 4.5 and greater than or equal to pH of 7.0. In summary, the influence of pH on the water absorption and retention properties of meat are widely reported and probably are minimum at the isoelectric point of meat protein, pH of 5.0 to 5.5, and increase in meat both at higher and lower pH values (Wierbicki 1959).

Sodium chloride in a meat product inhibits microbial growth, and in combination with curing agents, lowers the thermal processing requirements for a stable meat product (Niven and Chesboro 1960) as well as increases the swelling and degree of hydration of protein. Salt also solubilizes myosin from muscle fiber (Wilson 1960), therefore acts as a primary emulsifying agent. Kebede (1968) reported that sodium chloride improved the binding of meat and had no adverse effect on the finished poultry sausage product studied.

Froning (1966) found that polyphosphates significantly increased tear-strength of slices of chicken meat and

that the pH values were significantly higher in polyphosphate treated meat. Therefore, the increased pH, caused by the polyphosphates, probably influenced changes in the property of proteins, which subsequently altered the binding properties of meat. Froning (1965) stated that when color, flavor and texture were considered together, it was advisable to use 0.5% to 1.0% polyphosphate in ground chicken meat products and that 2.0% was unacceptable from a flavor standpoint. Kebede (1968) also reported that phosphate treated products had undesirable flavor and felt rubbery.

Smoking and Curing

Smoking and curing meat has traditionally been a combination of treatments for preservation purposes (Malcom et al. 1957). These treatments reduce moisture content, impregnate with salt, introduce smoke flavor, partially pasteurize the product and act as an antioxidant. However, the main function of smoking now is to supply flavor rather than to preserve (Schaible et al. 1940). Wilson (1960) also found that the only advantage of smoking a moist product was to impart a desirable color, to glaze and to improve organoleptic characteristics.

Malcom et al. (1957) reported further advantages for a smoked poultry product as: (1) it is a specialty meat; (2) it is firmer, a smoother more uniform texture makes it easier to slice; (3) it has distinguishing light pink (breast meat) to mahogany (dark meat) color versus the

appearance of cooked turkey; (4) it can be held for several days without refrigeration; (5) it can be stored for 3 months under refrigeration; and (6) it has excellent keeping quality when frozen (up to two years). Davidson and Dawson (1953) also noted smoked turkey rolls reduced the necessity for storing large quantities of heavy turkeys, keeping storage space per bird at a minimum.

The chemical composition of wood smoke is quite complex (Wilson 1960). Chemicals identified in smoke are aliphatic acids from formic through caproic, primary and secondary alcohols, ketones, formaldehyde, acetaldehyde, phenols, cresols and a mixture of waxes and resins. Today, few meat foods are produced in which smoke constituents play an important role in preserving the product against microbial spoilage (Wilson 1960) and at most, the smoke constituents penetrate only a few millimeters beneath the surface. When the product is sliced and pre-packaged, the bacteriostatic properties of the smoke constituents become inconsequential.

Meat smoking is normally accomplished by varying the amounts of heat, smoke and moisture present in a smokehouse. By varying these conditions, different intensities of smoke and degrees of pre-cooked or partially cooked smoked products can be obtained. Other methods of introducing smoke flavors include use of smoke-salt brines, dipping in smoke flavored liquids and using dry smoke flavored salts. Jackson and Stadelman (1955) reported that the main advantages of curing in smoked salt brines, without further regular smoke, were

the low cost of the process and minimal loss in weight. In addition both Jackson and Stadelman (1955) and Smith et al. (1943) reported that the flavor of poultry meat, i.e., smoke flavored without actual smoking, was equal to or superior to that processed by the smokehouse method. The improved flavor was normally associated with higher moisture content of the meat, reported to be about 7% higher after using a brine soaking process.

Curing meat helps to safeguard it against spoilage and gives it a distinctive flavor. Salt is a mild bleaching agent. When it is the only curing agent used, the product will be pale (Anon. 1954). Nitrites in the curing solution react with the myoglobin found in muscle protein and forms nitrosomyoglobin or red colored meat (Wilson 1960). Other ingredients, such as spices, can be added to the brine. However, Mountney (1966) reported that large amounts of either spices or salt would mask the mild flavor of the meat. Smith et al. (1963) also noted that salt tends to harden muscle fibers and to absorb water from them but the addition of sugar would counteract this dehydration and toughening action. Malcom et al. (1957) stated that turkey meat could be cured immediately after dressing, after chilling, or following freezing and thawing.

Cooking and Storage

Meat juices are released during heat treatments, and the amount of juice depends on the temperature. This loss of water influences the juiciness and texture of meat, Hamm et al. (1960). They also reported the effects of the step-wise change of water-holding capacity of meat during heating and the relationship between denaturation and the formation of new cross linkages due to the pH change. However, the release of meat juices is also affected by other factors. Froning (1965) reported that all binders tested, with the exception of gelatin, significantly reduced cooking losses. Cooking losses were also significantly lowered by polyphosphate treatment, and the polyphosphate treated meat was smoother, less crumbly and had improved texture when used up to 1%. Polyphosphates applied at a 2% level caused the meat to be rubbery and to have an unacceptable color and flavor.

Mickelberry and Stadelman (1960) reported that pre-cooked frozen chicken meat, baked in aluminum foil in a convection oven, yielded a more tender product than meat cooked by other methods of heating. Davidson et al. (1941) reported that cooking time for smoked turkey meat varied with age and the quality of birds. Goodwin et al. (1962) found that turkey meat cooked to an end-point temperature of 55°C had significantly higher shear values than meat cooked to 77°C or above, but the rate of cooking had no significant effect on shear values. Marquess et al. (1963) roasted

turkey rolls and stated that as oven temperatures were increased, yields of the cooked light meat rolls decreased. Statistical analysis indicated a highly significant linear effect of oven temperatures on yields of light meat rolls. van den Berg et al. (1963) compared light and dark chicken meat with respect to moisture and salt losses during cooking. They reported higher cooking losses from dark meat and attributed this to lower water content and salt binding ability in that tissue.

Keeping quality of pre-cooked frozen meats has been an important consideration in their distribution and use. Kahlenberg and Funk (1961) reported that the keeping quality depended on the way the meats were cooked, the methods of packaging, the type of seasoning and storage temperatures. The flavor of cooked meats can rapidly deteriorate during storage time (Tims and Watts 1958) and various terms such as "warmed over," stale or rancid have been used to describe these flavor characteristics. When this change in flavor of cooked meats is oxidative in nature, approved antioxidants, which become effective after heating, should be used. Tims and Watts (1958) studied the antioxidant effect of several phosphate salts on cooked meats and reported that pyro-tripolyphosphate and hexametaphosphate had protective effects; whereas, orthophosphate did not. Marion and Stadelman (1958) reported no significant differences in poultry cooking losses due to freezing methods.

Wilkinson et al. (1965) found that none of several pathogenic bacteria in turkey rolls studied survived an end-point temperature of 71°C (160°F), while only one strain, Streptococcus faecalis, survived an end temperature of 66°C (150°F). They also indicated total counts were reduced by successively higher temperatures (60°C) (140°F) to 79°C (170°F) and at an end temperature of 71°C (160°F) or higher, total counts had been reduced to 180 or fewer cells/gram of turkey meat. They concluded that there was little danger of food poisoning due to the pathogens studied when unfrozen turkey rolls were cooked to an internal temperature of 71°C (160°F).

Tenderness

Paul et al. (1959) reported variability in tenderness and high correlations between various tenderness measurement scores, number of chews, and shear values for chicken. However, the percent extractable nitrogen was not particularly useful for predicting tenderness in young chickens. In an attempt to define specific recommendations for assuring tenderness in cooked meat, Paul (1963) did not believe that there was a clear answer available from the research reported.

She suggested that the variation in type of animal, pre- and post-slaughter treatment, cuts or muscles tested, cooking methods, and methods of evaluation all were obvious

factors contributing to the variability and often contradictory results. Cover et al. (1962) supported this belief when they stated that tenderness in meat was not a simple one-component system but that two structural components, muscle fiber and connective tissue, were involved. Another dimension of tenderness is its relationship to water holding capacity, as discussed by Pearson (1963). However, he concluded that although meat which has a high water holding capacity tends to be more tender, the effect does not appear to be clear-cut and other factors seem to be more influential.

Pearson (1963) stated that both the Warner-Bratzler Shear and the Kramer Shear Press gave the best mechanical means of establishing the relationship of tenderness to sensory evaluating. Wells et al. (1962) reported that the difficulty of obtaining a core of chicken meat made the Kramer Shear Press more satisfactory. Fair-to-good correlations between qualified taste panels and Kramer Shear Press values have been reported by many researchers in measuring tenderness. Wells et al. (1962) also reported that maximum peak heights obtained from the Kramer Shear analysis were as accurate as measuring the area under the curve for non-dehydrated chicken.

Goodwin et al. (1962) reported that freezing, cooking and storage time affected tenderness of pre-cooked and raw turkey meat. They suggested that: (1) tenderness was one of the main criteria in consumer acceptance of a product; (2) freezing increased considerably the tenderness of

chickens that had been aged less than six hours; (3) age of birds, time of aging, class of poultry, temperature of aging media, and type of media used in carcass aging were important factors in post-mortem tenderization; (4) methods of cooking and storage time did not significantly affect the shear values; and (5) cooking prior to freezing resulted in significantly higher shear values indicating a toughening effect.

Taste Panels

Pearson (1963) recommended that consumer panels should consist of about 18 randomly selected members, the score card should be simple, and the number of factors evaluated should be limited. Dawson et al. (1963) reported that panel members tend to use all available information in making their judgments. Therefore, samples should be prepared and served as uniformly as possible in all aspects not related to flavor. Furthermore, they stated that the size of sample, temperature, texture and color must be controlled and, if possible, the product should be tasted by the panelist in the condition in which the food is normally consumed.

Highlands and Burns (1941) used a taste panel to evaluate smoked meat and reported that most people preferred a light smoke. They suggested that tasting fatigue be considered when tasting smoked products. However, in sensory testing of differences in taste, Dawson et al. (1963) reported that panel members made fewer mistakes in the second

half of a tasting experiment, indicating no taste fatigue under their conditions. They listed the advantages of multi-sample testing, or multiple comparison method over the triangle method as: (1) smaller differences between treated and untreated samples can be detected; (2) additional information about the direction and importance of differences is accumulated; (3) less time and fewer samples are required; (4) panels are more efficient when they are not selected or trained; and (5) small differences in color and texture do not influence results.

Marketing Potential

Brooks and Baker (1960) considered these factors important in affecting consumer use of ready-to-cook mature fowl: knowledge and interest in stewing chicken dishes, emphasis on ease and speed in food preparation and the place of purchase by homemakers.

Mountney (1966) suggested that poultry meat could make a very important contribution to the human diet because: (1) it is economical; (2) it is quick and easy to prepare and serve; (3) its low caloric content makes it ideal for weight control diets, for convalescents and for old people who are not physically active; (4) it is ideal for infants and young children; (5) it is higher in protein than red meats and contains all the essential amino acids presently known to be required in the human diet; and (6) finally poultry meat is low in fat and cholesterol.

Although several approaches for increasing the consumption of fowl meat have been described, Enochian and Rollag (1966) emphasized that it might be easier to expand the demand for some further-processed poultry than for whole or cut-up poultry. Mountney (1966) reported some smoke flavored further processed poultry products being sold in Pennsylvania in 1965. The products were smoked sliced chicken and smoked turkey rolls selling at retail prices of \$1.75/lb and \$2.25/lb, respectively.

Further expansion of the demand for such poultry products would help to increase the overall price of poultry and possibly fowl meat. This has been the only major food group that has shown a steady decline in prices since 1950 (Enochian and Rollag 1966). Whatever the approach used in marketing fowl meat, the importance of quality, followed by convenience and economy should be emphasized among new products developed. If the measurement of quality is based on fat, protein and caloric content poultry meat offers good opportunities (Swackhamer 1963).

PROCEDURES

Sources and Preparation of Chicken Rolls and Ingredients

Boned Leghorn fowl meat was obtained from the Polo Foods Company, Goshen, Ind. The birds were from a single flock to minimize product variation and were slaughtered, boned and frozen separately as light meat, dark meat and skin in 50 lb rectangular boxes. The frozen products were transported to East Lansing and kept frozen at -22°C until used.

The major constituent of the light meat rolls was boned breast muscle (Pectoralis major and minor) and of the dark meat rolls was thigh and drumstick meat.

The rolls were formulated with these ingredients:

	Dark (%)	Light (%)
Boned chicken meat	90.3	90.3
Ground skin	7.1	5.6
Soy protein concentrate	---	1.5
Poultry FOS*	0.5	0.5
Seasoning	1.2	1.2
Salt	0.9	0.9

*Poultry FOS (tradename) was dissolved in water and as a percent of total weight, dark = 4.7%; and light = 7.8%.

Sources of Seasoning--Additives and Smoke Flavors

CharOil (Heller)--oil-base natural smoke flavor.

CharSol (Red Arrow)--natural smoke flavor used for dipping.

CharZyme (Red Arrow)--dry powder, smoke flavor.

Chicken roll seasoning (Griffith)--salt, hydrolyzed plant protein, monosodium glutamate, dextrose, spice extractives of pepper, onion and garlic powder, pepper, turmaic and other spices.

Poultry FOS (Griffith)--processed from sodium tripolyphosphate, tetrasodium pyrophosphate, monosodium phosphate, sodium hexametaphosphate.

Salt (Morton Salt)--Culinox 999, food grade.

SF-12 (Griffith)--natural smoke flavor used in the curing solution.

Sodium nitrate (Allied Chemical)--reagent grade.

Sodium nitrite (Allied Chemical)--reagent grade.

Soy protein concentrate (Griffith)--GL-301.

Meat Preparation

The skin, in a semi-frozen state, was ground twice through 0.95 cm (3/8 in) plate and twice through 0.16 cm (1/16 in) plate in a Toledo High Speed Chopper, Model 5520. Both the dark and light meat were cut in a semi-frozen state. The dark meat was chopped once through a Buffalo Stand Silent Cutter, Model 23-B, and the light meat was cut by hand into three equal pieces per breast muscle at right angles to the muscle fibers.

The meat and skin were placed in a 113.6 l (30 gallon) stainless steel multiple paddle mixer and mixed at slow

speed. The poultry FOS, dissolved in tap water, was added to the meat and skin and mixing continued. The salt and seasonings were then added and the soy protein concentrate added last (light meat rolls only). Each batch consisted of 5.9 kg (13 lbs) of meat and skin to make six 0.9 kg (2 lb) rolls, and mixing was continued for approximately 15 minutes after all the ingredients were added.

Preparation of Rolls

Forty-two light meat and 42 dark meat rolls were made in a similar manner. A minimum of 0.9 kg (2 lbs) of meat for each roll was placed in a 50.8 cm (20 in) length of fine stockinette, which in turn was placed in a 38.1 cm (15 in) length of No. 16 Zip-Net (C. K. Mfg. & Sales Co.). Each roll was cylindrically shaped by hand and compressed into the stockinette,¹ held in place by a Zip-Typer (C. K. Mfg. & Sales Co.). The firm roll was tied, then further patted and compressed to increase meat contact. Each roll was approximately 22.9 cm (9 in) long and 8.6 cm (3.4 in) in diameter.

Smoking and Curing

Based on preliminary studies and product manufacturer's recommendations, an acceptable mild smoke flavoring was the standard objective for the prepared rolls.

¹Stockinette refers to both the fine stockinette and Zip-Net.

Curing was accomplished by following the formula for a "simple" cure as suggested by Koch Supplies (Anon. 1954) and Jackson and Stadelman (1955). Seven different methods were used to produce a cured and/or smoke flavored product from both light and dark meat. The brine curing solution contained 11.4 l (3 gal) of water, 1.8 kg (3.99 lbs) salt, 0.7 kg (1.5 lbs) sugar, 68.0 gm (2.4 oz) sodium nitrate, and 8.5 gm (0.3 oz) sodium nitrite. The solution had a salometer reading of 55 degrees and was prepared with cold tap water then held at 4°C for 24 hours before use.

Meat Roll Treatments

- 1) Brine cure and smoke dip--Rolls were held 25 hours in the brine solution at 4°C, removed, drip dried, then completely immersed for 10 seconds in concentrated CharSol and cooked.
- 2) Smoke flavored brine--Regular brine cure had 85.0 gm (3 oz) SF-12 added per 3.8 l (1 gal) of solution. The rolls were soaked 25 hours at 4°C, removed and drip-dried, then cooked.
- 3) Brine cure and smokehouse--Rolls were held 25 hours in brine cure, removed and drip dried, placed in smokehouse with wet bulb set at 35°C and the dry bulb at 49°C (relative humidity of 40%). The rolls were smoked 4 hours in a dense smoke and were held at 4°C until cooked.
- 4) Brine cure and oil-base--Rolls containing 0.375%, by weight, CharOil (blended during processing) were placed in brine for 25 hours, removed, drip-dried and cooked.

5) Oil-base--Rolls contained 0.375% CharOil, by weight, blended during processing, were held at 4°C for 55 hours and cooked.

6) Dry smoke flavoring--Rolls had 1.0%, by weight, CharZyme added during processing, held at 4°C for 55 hours and cooked.

7) Control--Rolls contained no smoke or cure, and after processing, were held at 4°C for 55 hours and cooked.

Cooking and Storage

The rolls were cooked in a convection oven (Etco Oven, Market Forge Co., Model 186C.2) at 121°C until the slowest heating point reached an internal temperature of 74°C. Thermocouples were placed at different angles to reach the central axis for temperature measurement. Approximate cooking time averaged 1 hour and 35 minutes.

The samples were vacuum packed in cryovac bags and sealed on a Cryovac Bag Sealer, Model No. 6153 B, then double clipped to close. The rolls were held at 4°C at all times except when processed, cooked or evaluated. Cooked samples, held at 4°C, were analyzed at intervals of one, seven and fourteen days after cooking. Other samples, after vacuum packaging in cryovac bags, were frozen immediately in a moving air walk-in freezer at -22°C and were held for analysis after 21, 28 and 35 days.

Evaluation of Chicken Rolls

Bacteria Counts

Samples for plating were taken from the meat before it was placed in stockinettes, and before serving the taste panel (at one week intervals) and were placed in sterilized jars and held at 4°C until plated. An 11.0 gm sample of meat was blended with 99 ml of sterile distilled water in a Waring Blendor at high speed for 2 minutes. Dilutions ranged from 1/10 to 1/1,000,000, and 10 to 15 ml of tryptone glucose yeast agar were added followed by incubation for 2 to 3 days at 32°C. Total plate counts were determined on a colony counter.

Crude Fat

The general procedure followed for crude fat determination was that suggested by Triebold and Aurand (1963). A dry extraction process was followed using a Soxhlet apparatus. A 10 gm sample was taken after it had been ground three times through a 0.95 cm (3/8 in) grinding plate and then dried for 12 hours at 100-102°C. The dried samples were extracted with anhydrous ethyl ether and the dissolved fat collected in a tared flask. The sample was extracted for 24 hours, then the ether was evaporated over a steam heated water bath. Finally, the samples were oven dried at 100°C to drive off any remaining water.

$$\% \text{ Crude Fat} = \frac{\text{Weight of Crude Fat}}{\text{Sample Weight}} \times 100.$$

Kramer Shear Press

An Allo Kramer Shear Press, Model Sp-12, was used to mechanically measure the tenderness of the rolls. The Kramer Shear Press with a 1363.3 kg (3000 lb) ring, range setting 20 and speed of 30 seconds was used to measure the maximum pressure required to force the shearing ram through pieces which weighed approximately 100.0 gm each. A pressure-time curve was obtained from the recorder, and this curve was used to calculate the work required to shear the product. The peak of the curve was reported as being as accurate as the area under the curve (Wells and Dawson 1966), and therefore, these peak readings were used in the analysis of variance and simple correlation tests.

Moisture Analysis

A sample of each treatment was taken of the raw products, then at one week storage intervals after cooking. Approximately 50 gm of meat was ground three times through 0.95 cm (3/8 in) grinder plate, then two 10 gm samples were removed for drying and placed in tared aluminum drying pans before weighing to four places on a Mettler Balance. The samples were dried for 12 hours at 100-102°C, and then placed in a desiccator until sufficiently cooled for the final weighing.

$$\% \text{ Moisture} = \frac{\text{Original Sample Weight} - \text{Dry Weight}}{\text{Original Sample Weight}} \times 100.$$

Peroxide Value

The basic procedure used to determine peroxide values was that outlined by Stine (1954) except for the de-emulsification procedure reported by Pont (1955). Slight variations were made due to the nature of the meat product and the difference in fat levels between the light and dark meat.

A meat sample was removed from each roll before it was prepared for taste panel evaluation, after storage intervals of 1, 14 and 35 days. This sample was held in a brown bottle at 4°C until analyzed. Using 30 gm of dark meat or 100 gm of light meat and 60 ml of distilled water (200 ml for light) the sample was blended for 30 seconds at high speed in a Waring Blendor. Fifteen ml of de-emulsifying agent¹ (50 ml, light) was added to the slurry, and the combined mixture was gently swirled before placing into two 300 ml polyethylene sample bottles. The sample bottles were then heated for 10 minutes at 70°C in a water bath, and mixed occasionally.

The samples were then centrifuged for 2 minutes at 2500 r.p.m.'s and the liquid portion was transferred to a 50 ml volumetric flask. Hot distilled water was added, bringing the fat up into the neck. The flasks were

¹De-emulsifying agent was 50 gm sodium citrate, 50 gm sodium salicylate and 86 ml n-butanol dissolved in distilled water to make 450 ml.

centrifuged for one minute at 1000 r.p.m.'s (with supportive cushioning holding the neck upright) and the fat was tempered 5 minutes at 45°C before pipetting off the fat layer into glass-stoppered storage bottles. The fat was held at 4°C prior to the determination of the peroxide value.

A 0.5 ml sample (0.458 gm) of the collected chicken fat was removed from the sample bottle with a 0.5 ml Ostwald-Folin pipette and placed in a 10 ml standard tapered volumetric flask. A benzene-methanol¹ solution was added to the mark and the stoppered flask was inverted several times to dissolve the fat. Further dilution was necessary for most samples, that is 1.0 ml of the 10.0 ml dilution was removed and again diluted in a 10.0 ml volumetric to the mark with benzene-methanol. However, the solution was mixed very rapidly and then the following steps were performed. One drop of ferrous chloride,² followed by one drop of ammonium thiocyanate reagent³ was added to the mixture in the flask and the flask shaken vigorously to disperse the reagents. The flask was immediately placed in a water bath at 50°C for exactly two minutes for the color to develop. The

¹Benzene-methanol solvent was made up of 70 volumes of thiophene free benzene and 30 volumes of C. P. methanol. The benzene was redistilled and the methanol was dried by refluxing for 4 hours with 5 gm of magnesium ribbon per liter, followed by distillation.

²Ferrous chloride solution was 0.014M and stored in a brown bottle.

³Ammonium thiocyanate reagent, 30 gm added to 100 ml distilled water.

temperature was lowered to approximately room temperature in two minutes in an ice bath. The mixture was transferred to a cuvette and the light transmission determined at 505 m μ on a Spectronic 20 Colorimeter (Bausch and Lomb) adjusted to 100% transmittance with the benzene-methanol solution. A fat blank was run on the sample of the extracted fat in precisely the same manner except that no ferrous chloride reagent was added.

In calculating the peroxide value the specific gravity of chicken fat was taken as 0.916 (same as lard) given by Swern et al. (1964).

$$\text{Peroxide Value} = \frac{\text{Net micrograms Fe per 10 ml}}{\text{Grams of fat used} \times 55.84}$$

(then the peroxide value is in meq of O₂/kg of fat).

Taste Panel

The taste panel consisted of 20 members selected at random from the available graduate students, technicians and staff of the Food Science Department. At least 15 members participated in all four tasting sessions for both the dark and light meat. The taste panel evaluated all dark or all light meat during separate sessions, which were scheduled 1, 7, 21 and 35 days after processing both dark and light meat. The taste panels were conducted at the same time each day.

Each panel member received seven different cellophane wrapped meat samples on two plates. The meat samples were sliced approximately 0.32 cm (1/8 in) in thickness

using a mechanical slicing machine. About one-fifth of a slice (4.6 sq cm or 1.8 sq in) from each treatment was served to each panel member. The samples were numbered using a random number table, and the order of samples was changed each session. Each sample was rated on the basis of its smoke intensity, juiciness, tenderness and overall desirability using a 7-point hedonic preference scale. A rating of 7 was highest, and 1 was the lowest rating a particular sample could receive for each of the four characteristics evaluated.

Yield Values

Each roll was weighed before and after the following operations: (1) stuffing into the stockinettes; (2) thorough draining following curing and/or smoking; (3) cooking; and (4) before serving. The net weight was determined by subtracting the average weight of the stockinette.

$$\% \text{ Yield} = \frac{\text{Net weight of sample}}{\text{Original weight}} \times 100.$$

Statistical Procedures

The statistical procedures used were the analysis of variance, Duncan's Multiple Range Test for the separation of means, and simple and multiple correlation analysis (Snedecor and Cochran 1967).

The data were analyzed on a CDC 3600 computer using STAT routines available from the Michigan State University

Agricultural Experiment Station. These programs were standard statistical procedures applicable to this research information.

RESULTS AND DISCUSSION

Preliminary trials established the level of ingredients, processing techniques, and cooking procedures used to produce the dark and light chicken meat rolls for evaluation. The selection of ingredients and the specific proportions used were based on a modification of a formula supplied by Griffith Labs (1968), as determined by informal taste panel tests, acceptable binding properties, and favorable overall appearance. The level of smoke applied during each treatment was designed to yield a mild smoke flavor. Smoke intensity levels were determined by modifying the manufacturer's recommendations for the ingredients after preliminary evaluations.

The final binding characteristics were affected by the combination of ingredients, meat preparation procedures and the elastic stockinette used to hold the pieces of meat together during cooking. The soy protein concentrate had good water binding properties but was not used in the dark meat because of an objectionable color and a maximum of 1.5% was incorporated into the light meat due to an off-flavor. The amount of ground skin was limited because it gave an oily appearance to the cooked and sliced dark meat rolls when served cold.

Objective Analyses of Smoked Rolls

Bacterial Analyses

The numbers of viable bacteria from raw chicken meat and from samples of each cure and/or smoke treatment are reported in Table 1. Total plate counts from the uncooked dark meat product ranged from 7.6×10^4 to 17.8×10^4 organisms per gram of sample. The total number of organisms was reduced substantially after cooking (range: 360 to 520 organisms/gm dark meat) and remained relatively low throughout all storage time tested. The cured samples (dipping, soaking, smokehouse, and oil base and cure) had, on the average, fewer organisms present than did the uncured samples. However, the final plate counts for all treatments were still very low and appeared very acceptable. The total plate counts observed for the cooked rolls were similar to the 180 cells/gm or lower reported by Wilkinson et al. (1965) for turkey rolls cooked to an internal temperature of 71°C or higher.

The bacterial numbers in uncooked light chicken meat rolls varied from 1.5×10^4 to 9.8×10^4 cells/gm. Again, the cured samples had fewer numbers of organisms present than did the uncured rolls after cooking, but all samples had acceptably low total bacteria counts. The dark meat rolls had fewer numbers of organisms (1900 cells/gm) as an average of all treatments and storage times after cooking, than did the light meat rolls (12,800 cells/gm). There was

Table 1. Total plate counts of bacteria from dark and light chicken meat rolls, raw and cooked, from each treatment, during unfrozen and frozen storage

Treatments	Storage conditions and time (days)						
	Unfrozen				Frozen		
	Raw	1	7	14	21	28	35
Number of bacteria (100's)							
<u>Dark Meat</u>							
Dipping	960	4.1	14.0	13.9	3.6	---	6.4
Soaking	990	4.7	10.0	8.5	4.0	---	8.4
Smokehouse	1780	3.9	24.0	3.8	4.3	---	6.7
Oil base & cure	1740	5.2	27.0	8.5	6.1	---	3.1
Dry smoke	760	4.4	19.0	10.7	69.0	---	7.1
Oil base	970	3.6	19.0	15.1	31.0	---	45.0
Control	880	4.5	4.0	45.0	24.0	---	58.0
<u>Light Meat</u>							
Dipping	980	6.0	---	2.6	2.7	2.8	178.0
Soaking	460	9.4	---	83.0	3.6	4.9	5.8
Smokehouse	550	30.0	---	7.0	3.8	7.0	13.5
Oil base & cure	147	3.8	---	15.0	12.6	28.0	27.0
Dry smoke	500	26.7	---	401.0	2.1	3.6	470.0
Oil base	570	31.0	---	360.0	67.0	300.0	62.0
Control	760	12.3	---	410.0	250.0	310.0	40.0

also greater variation in the bacteria counts from the light meat than from the dark. However, the final bacteria counts for both the dark and light meat rolls were relatively low and should not have had an appreciable effect on the keeping quality or the flavor of the rolls.

Moisture Analysis

Table 2 gives the percentage moisture of the dark and light chicken meat for various treatments and storage times and temperatures. It is apparent that the light meat

Table 2. Moisture content of unfrozen and frozen dark and light chicken meat rolls, for various treatments, storage conditions and time

Treatments	Storage conditions and time (days)						Average
	Unfrozen			Frozen			
	1	7	14	21	28	35	
% moisture							
Dark Meat							
Dipping	59.3	63.0	61.4	61.7	60.6	60.5	61.1
Soaking	63.4	61.9	60.6	60.9	59.2	61.3	61.2
Smokehouse	62.8	60.3	60.3	60.3	60.0	59.1	60.5
Oil base & cure	61.2	61.4	61.9	60.1	61.2	61.0	61.1
Dry smoke	63.0	63.4	63.2	63.0	62.9	63.8	63.2
Oil base	64.5	64.8	66.6	67.8	64.4	65.0	64.4
Control	64.1	65.1	63.4	66.3	65.1	62.3	65.5
Light Meat							
Dipping	64.2	66.9	65.4	66.2	65.8	65.7	65.7
Soaking	66.7	66.3	65.3	67.2	66.7	65.3	66.3
Smokehouse	65.2	67.3	66.1	66.3	65.3	66.3	66.1
Oil base & cure	66.8	67.8	65.0	66.7	66.6	65.2	66.4
Dry smoke	68.5	68.8	67.3	68.2	67.5	66.5	67.8
Oil base	69.6	69.6	66.9	68.5	67.6	68.0	68.4
Control	69.0	69.0	67.3	66.6	66.7	67.0	67.6

contained more moisture, on the average, than did dark meat. The moisture component of the chicken rolls is important because of its influence or interaction with binding, juiciness and keeping quality. Although the relationship between the amount of moisture present and the perceived juiciness is complex, it will be useful to compare the different moisture levels of products from each treatment. A later section will discuss the correlations between moisture and some of the other characteristics measured.

The influence of treatment on the moisture content of the refrigerated and frozen samples is significant at 0.05% level (Table 3). Table 4 shows a separation of the moisture mean values at a 1% level. The oil base and control samples contained significantly more moisture than the other samples of dark meat and the oil base, control and dry smoked samples contained significantly more moisture than samples in all other treatments for both dark and light meat.

Table 3. Analysis of variance of percentage moisture in dark and light chicken meat samples from all storage periods

Source of variation	D.F.	Sum of squares	Mean square	F	S ^a
<u>Dark Meat</u>					
Time	5	7.213	1.443	1.063	0.400
Treatment	6	137.292	22.882	16.865	<0.0005
Error	30	40.705	1.357		
<u>Light Meat</u>					
Time	5	15.402	3.080	5.576	0.001
Treatment	6	38.158	6.360	11.513	<0.0005
Error	30	16.572	0.552		

^aLevel of significance.

It is very apparent that the cured samples had less moisture than the uncured ones with the smokehouse application having the least moisture in all dark meat tested and second lowest in light meat. There was a significant difference in moisture (1% level) between the rolls which were brine cured and those which were not. However, the null hypothesis that no

Table 4. Average percentage moisture in dark and light meat samples from all storage periods^a

Average percentage moisture from different treatments							
	Oil base						
	Smokehouse	Dipping	Soaking and cure	Dry smoke	Control	Oil base	
	60.48	61.05	61.10	61.20	63.23	64.38	65.51
<u>Dark Meat</u> <u>significance</u> 1% level							
	Oil base						
	Dipping	Smokehouse	Soaking and cure	Oil base and cure	Control	Dry smoke	Oil base
	65.69	66.07	66.23	66.34	67.61	67.81	68.36
<u>Light Meat</u> <u>significance</u> 1% level							

^aDuncan's Multiple Range Test.

significant differences were found over time for the dark meat rolls had to be accepted as shown by Table 3. Therefore, under the testing conditions for the dark meat, no significance was observed when comparing samples that were unfrozen with those frozen.

The cured light meat samples also contained significantly less moisture than the uncured samples. There was some variation within each group in the rank order of percentage moisture in dark meat as shown by Table 4, however the three uncured processed rolls had more moisture than the cured. A significant difference in the analysis of variance test over time was found (Table 3). However, the relationship did not distinguish between unfrozen or frozen samples but separated them merely in a seemingly random fashion.

Moisture is generally recognized as one quality characteristic related to juiciness, water-binding, and cooking yields. Measuring total moisture by drying for 12 hours at 100-102°C does not separate free from bound water. However, it is a useful analytical technique when correlated with other quality factors and thus can be used to provide information about acceptability, storage, or keeping quality.

Moisture Lost During Cooking

Product yield after cooking is an important quality characteristic and is related to the percentage moisture lost during this process. The dark meat rolls, subjected to the smokehouse treatment, had the highest average moisture

loss and those for the oil base treatment lost the least (Table 5). Variation among treatments in average moisture loss was less than 5% for 6 of 7 dark meat treatments. These values were relatively similar to those reported by Marquess et al. (1963), who found a loss of 33.9% from dark meat turkey rolls cooked at an oven temperature of 250°F (121°C) to an internal temperature of 176°F (80°C). Table 6 shows that a significant difference in cooking losses was found for both dark and light meat due to the treatment.

Table 5. Percentage moisture lost during cooking of dark and light chicken meat rolls by treatment

Treatment	Sample number						Average
	1	2	3	4	5	6	
% Moisture lost							
Dark Meat							
Dipping	27.4	24.3	30.0	29.7	34.2	32.0	29.6
Soaking	27.5	28.8	29.9	31.1	29.8	31.6	29.8
Smokehouse	36.3	36.7	37.2	33.4	36.5	28.3	34.7
Oil base							
and cure	35.2	35.3	31.8	32.1	32.1	31.4	33.0
Dry smoke	28.9	27.7	28.8	28.9	30.5	32.0	29.5
Oil base	22.6	24.3	16.0	10.9	25.9	19.3	19.8
Control	30.3	28.5	34.2	31.9	32.2	30.2	31.2
Light Meat							
Dipping	20.7	20.4	22.5	20.0	22.6	23.6	21.6
Soaking	17.4	18.6	19.7	18.6	15.5	19.9	18.3
Smokehouse	18.7	16.6	16.6	18.4	20.1	15.6	17.7
Oil base							
and cure	18.6	19.2	21.5	16.0	12.9	19.4	17.9
Dry smoke	18.7	19.3	18.6	17.9	21.3	22.6	19.7
Oil base	14.9	13.2	17.3	18.5	21.4	17.7	17.1
Control	16.3	17.4	19.7	22.1	23.5	23.5	20.4

Table 6. Analysis of variance of the percentage moisture lost during cooking of dark and light chicken meat rolls

Source of variation	D.F.	Sum of squares	Mean square	F	S
<u>Dark Meat</u>					
Treatment	6	814.956	135.826	14.14	0.001
Error	35	336.165	9.605		
<u>Light Meat</u>					
Treatment	6	97.592	16.265	2.998	0.025
Error	35	189.884	5.425		

The Duncan's test (Table 7) for the dark meat rolls shows no significant difference in moisture loss (5% level) among the smokehouse, oil base and cure and control samples. The sample with the lowest moisture loss was significantly lower (5% level) than all others. The oil base treated rolls lost an average of only 19.8% moisture during cooking. This is a very low value, however, all replicate values were low.

Less variation in moisture loss was found among the light meat rolls than among the dark meat rolls. Again, the oil base treated rolls had the lowest percentage moisture loss, but, as indicated by Table 7, this value was not significantly different (5% level) from the values of 5 of the 6 other treatments. The average moisture losses are similar to those reported by Marquess et al. (1963) for light meat turkey rolls in which average moisture loss was 21.9% when products were cooked at 250°F (121°C) to an internal temperature of 176°F (80°C). In summary, both the dark and light

Table 7. Average percentage moisture lost during cooking for dark and light chicken meat rolls as influenced by treatment^a

	Treatments				
	Oil base	Dry smoke	Dipping	Soaking	Control
	Oil base and cure	Smokehouse			Smokehouse
	19.8	29.5	29.6	29.8	31.2
					33.0
					34.7
Dark Meat					
significance					
at 5% level					
Light Meat					
significance					
at 5% level					

^aDuncan's Multiple Range Test.

meat chicken rolls gave comparably good cooking yields. These improved yields might be expected from the addition of polyphosphates, the presence of soy protein concentrate in the light rolls, the low temperature during cooking, and wrapping the rolls in heavy aluminum foil.

Peroxide Values

Table 8 shows the peroxide values, in milli-equivalents of oxygen per kilogram of fat, for both dark and light meat rolls. The peroxide values of the fat extracted from the dark meat increased over storage time. The cured samples had lower initial values and were generally lower throughout the storage period than the uncured samples, but this was not a very clear relationship. Only one taste panel member reported one dark meat sample as "stale." Three of the 7 samples had higher peroxide values after 14 days in unfrozen storage, while 4 had higher values after 35 days of frozen storage.

The fat from light meat samples gave higher initial peroxide values than dark meat from all but one treatment. The peroxide values of all samples analyzed increased during storage. However, 5 of 7 samples had higher peroxide values after 14 days unfrozen storage than after 35 days in frozen storage. No apparent difference was found between the cured and uncured light meat samples, as was found in the dark meat. No comments by the taste panel members were made which might indicate the presence of oxidative rancidity in the light meat. Although the peroxide values increased

Table 8. Peroxide values of fat from dark and light chicken meat samples for various treatments after different storage conditions and times

Treatments	Storage conditions and time (days)		
	Unfrozen		Frozen
	1	14	35
Peroxide value--meq. of O_2 /Kg of fat			
<u>Dark Meat</u>			
Dipping	.59	11.74	6.72
Soaking	.36	3.88	7.19
Smokehouse	.46	2.70	9.78
Oil base & cure	.27	1.98	11.59
Dry smoke	9.72	11.16	9.63
Oil base	2.33	2.69	9.63
Control	1.23	13.30	11.74
<u>Light Meat</u>			
Dipping	2.41	11.74	9.94
Soaking	2.92	11.32	10.72
Smokehouse	2.69	10.33	8.34
Oil base & cure	2.45	8.23	5.44
Dry smoke	2.16	11.16	12.17
Oil base	2.96	7.72	6.69
Control	3.19	8.82	9.63

during storage, they were not high enough to be objectionable to the taste panel members (for either dark or light meat).

The peroxide values were obtained to measure objectively any change in oxidative rancidity. The presence of warmed over, stale, or rancid flavors has been reported as a problem sometimes associated with cooked meats. Thus cooked meats may receive high palatability ratings immediately after cooking, but oxidative changes in the fat can lead to a rapid deterioration in flavor during storage.

Oxidative rancidity may be reduced by the addition of antioxidants, such as several phosphate salts including pyro, tripoly, and hexametaphosphate (Tims and Watts, 1958). Therefore, the addition of poultry FOS to the chicken rolls could explain the absence of obvious oxidative rancid flavors. The poultry FOS used contained all three phosphate salts reported as effective antioxidants. The phosphates were also used to improve the yield or water-binding capacity, and could be used as preservatives in the rolls.

Tenderness Measurement--Kramer Shear Press

The Kramer Shear Press measures mechanical force to shear meat and is used to indicate tenderness. Tenderness was reported as the most important item in consumer acceptability (Pearson 1963). If tenderness, as recognized by consumer acceptability, can be accurately related to an objective measurement, then rapid, reliable and efficient tenderness measurements could be used more effectively in quality control. Many researchers, including Klose et al. (1959) and Burrill et al. (1962), have reported on the relationship and correlation between taste panel evaluations of tenderness and objective measurements. The simple correlation between shear press values and other characteristics will be discussed in a later section.

Table 9 reports the Kramer Shear Press values, in peak height measurements, indicating the force required to measure the tenderness of the dark and light chicken meat

Table 9. Kramer Shear Press values from dark and light chicken meat samples for various treatments, unfrozen and frozen storage conditions, and times

Treatments	Storage conditions and time (days)					
	Unfrozen			Frozen		
	1	7	14	21	28	35
Shear values in peak heights in mm						
<u>Dark Meat</u>						
Dipping	65.8	77.5	66.8	79.7	77.0	58.0
Soaking	75.7	73.0	63.5	73.0	71.6	78.7
Smokehouse	71.6	72.6	66.0	74.8	76.0	75.2
Oil base						
and cure	71.1	73.7	75.4	70.2	63.8	63.2
Dry smoke	60.7	65.2	63.5	67.5	60.5	60.7
Oil base	70.0	59.1	58.7	69.1	64.0	60.2
Control	76.8	59.1	58.8	62.2	56.3	62.6
<u>Light Meat</u>						
Dipping	63.0	57.7	68.7	65.8	63.0	66.0
Soaking	68.3	64.7	63.6	67.0	64.7	72.5
Smokehouse	56.4	61.4	71.6	65.5	63.3	69.4
Oil base						
and cure	67.6	59.0	62.6	58.8	58.8	58.4
Dry smoke	54.4	47.6	54.6	62.2	58.7	64.3
Oil base	54.1	58.2	58.7	56.5	60.8	63.2
Control	64.1	46.6	57.5	59.2	60.9	59.4

samples. Table 10 indicates that there is a significant difference ($S = 0.004$) in shear force values of dark meat among the various treatments. In Table 11, a rank order of the average shear values by treatment, is listed from low to high. The lowest dark meat score was received by the control sample and the highest by the smokehouse sample. A significant difference (5% level) was found between the four cured samples and the three uncured samples. The uncured samples were more tender. Table 10 indicates that no

Table 10. Analysis of variance of Kramer Shear Press peak heights for light and dark meat samples from all storage times

Source of variation	D.F.	Sum of squares	Mean square	F	S
<u>Dark Meat</u>					
Time	5	223.981	44.796	1.481	0.225
Treatment	6	761.558	126.926	4.198	0.004
Error	30	907.150	30.238		
<u>Light Meat</u>					
Time	5	261.683	52.337	3.167	0.021
Treatment	6	516.657	86.109	5.211	0.001
Error	30	495.780	16.526		

significant difference in shear force was found due to storage time ($S = 0.225$). This means that there was no distinguishable difference between the dark meat chicken rolls which were frozen and those which were unfrozen. This does not agree with the findings of Goodwin et al. (1962a), in which they reported that cooking prior to freezing resulted in significantly higher shear values . . . indicating a toughening effect. This was more prevalent for the thigh meat than for the breast meat.

The rank order of average shear values of light meat was similar to that of dark meat, especially relative to curing treatment (Table 11). The dry smoke light meat samples were most tender and the soaked samples were toughest. The range between the low and high average values for both the light and dark chicken meat rolls was approximately 10 mm. However, the light meat samples were obviously more

Table 11. Average peak heights for Kramer Shear Press values of dark and light chicken meat for different treatments at all storage periods^a

	Treatments				
	Control	Dry smoke	Oil base	Oil base and cure	Dip-ping
					Soak-ing Smokehouse
<u>Dark Meat</u> significance at 5% level	62.62	63.02	63.52	69.57	70.80
			Average peak heights (mm)		
				72.58	72.70
	Treatments				
	Dry smoke	Control	Oil base	Oil base and cure	Dip-ping
					Soak-ing Smokehouse
<u>Light Meat</u> significance at 5% level	56.97	57.95	58.58	60.87	64.03
			Average peak heights (mm)		
				64.60	66.80

^aDuncan's Multiple Range Test.

tender than the dark. This is in agreement with Goodwin et al. (1962), who found that shear values for breast muscles were significantly lower ($P < 0.01$) than those for the thigh muscles. A significant difference (5% level) was found in shear values of meat between the four cured samples and the three uncured samples. However, the shear values of oil base and cure rolls were obviously between the two extremes and were not significantly different (1% level) from any other sample. Table 10 indicates that the Kramer Shear values of light meat were significantly different ($S = 0.021$) due to storage time. The order of average shear values from high to low was ranked by days as follows: 7 1 28 21 14 35. The samples stored 7 days had a significantly higher value than all others (5% level). Although the frozen samples (days 21, 28, and 35) had high shear values, this does not clearly support the findings of Goodwin et al. (1962) as previously discussed. In summary, the light meat was more tender than the dark meat. The rank order of average shear press values by treatment was similar for dark and light meat, and the uncured samples were more tender than the cured samples.

Subjective Analyses of Smoked Rolls

Binding Properties

The binding scores of the dark and light meat rolls, based on a 1 to 5 point scale, are reported in Table 12. The subjective analysis was designed to evaluate the binding qualities associated with each treatment and storage interval. The cold product sliced evenly and held together well. Some small holes were present in the slices of dark chicken rolls, possibly due to separation of the pieces of meat during cooking and/or only partial contact between the pieces during cooking. Aref (1966) reported that one difficulty in obtaining a desirable roll was the necessity of getting the pieces of meat to touch each other while the binder was producing its effect.

Although the frozen samples felt softer, after thawing, with less body than did those which had been stored unfrozen (4°C), no distinguishable differences were observed in the binding qualities in terms of slicability or the cohesiveness of the slices. Apparently the cell destruction expected from the rather slow freezing conditions applied was not sufficient to influence the binding qualities when compared to those of unfrozen rolls.

Most of the light meat samples received binding classification ratings of 4+ to 5 (very good to excellent). They exhibited good slicing properties, as did the dark rolls, but held together better, on the average, than the

Table 12. Evaluation scores^a of the binding quality for dark and light chicken meat rolls after various treatments and storage intervals

Treatments	Storage conditions and time (days)					
	Unfrozen			Frozen		
	1	7	14	21	28	35
Binding scores ^a						
<u>Dark Meat</u>						
Dipping	4	4+	4-	4	4	4+
Soaking	4	4	4	4-	4+	4-
Smokehouse	4	4	4	4	4	4
Oil base and cure	4	3	4	3	4	4+
Dry smoke	3	3	3+	3-	3-	3+
Oil base	4	4	4	4	4-	3+
Control	4+	4-	4+	3	4	4
<u>Light Meat</u>						
Dipping	5	5-	5	4	4	4
Soaking	4+	5	5	5	5	5
Smokehouse	5	5	5	5-	5	4+
Oil base and cure	4	5	5	5	5	5-
Dry smoke	5	5-	5	4	5	5
Oil base	5	5	4+	5-	5	5-
Control	4+	5-	5	5-	5-	5

^aBinding scores based on subjective standard of comparison using 1 (minimum) to 5 (maximum) points per sample analyzed.

dark. There were no apparent or obvious differences in binding between the samples from different treatments or due to the storage conditions for the light meat. The light rolls had better binding characteristics than dark meat, had less separation of pieces, and there was less evidence that individual slices were composed of small pieces of meat. The superior binding properties of the light meat could be expected because of the higher percentage of protein in

light meat compared with dark meat, as reported by Baker et al. (1966).

The moisture:protein ratios as well as the fat:protein ratios are important in defining the binding properties of meat products of this nature. Table 13 indicates that the percentage of fat in the cooked dark meat was higher than that in the light meat as determined by 12 fat extractions for each type of roll. Dark meat had more than twice as much fat as the light meat, which is similar to the information presented by Baker et al. (1966).

Table 13. Average percentage fat in cooked dark and light meat samples for cured and uncured treatments at all storage intervals

	Treatment	
	Uncured	Cured
	% Fat	
Dark Meat	9.4	10.0
Light Meat	3.8	3.8

The combination of factors, including cutting the meat across the muscle to increase surface area and contact, addition of salt, addition of polyphosphates, use of elastic stockinette and the addition of soy protein concentrate in the light meat resulted in very acceptable binding for the chicken rolls. The light meat showed better binding characteristics than the dark meat but both were very acceptable.

Taste Panel Evaluation

Each taste panel was composed of twenty members who tasted samples of both dark and light meat rolls after four storage intervals. Samples from the seven treatments were evaluated for four quality attributes: smoke intensity, juiciness, tenderness, and overall desirability using a 7-point hedonic preference scale.

Even though an obvious difference exists in the ratings given by the taste panel judges between dark and light meat and among the four quality characteristics, a five-way analysis of variance test (not presented) indicated both of these differences were significant ($S = < 0.005$). Therefore, the separation of dark from light meat as well as the separation of the four quality characteristics is statistically permitted in the remainder of the analyses.

Table 14 reports statistical data in a three-way analysis of variance (AOV) for the dark and light meat, taste panel members, treatments and storage times. This table shows that a significant difference ($S = < 0.005$) was found in scores for dark and light meat between taste panel members. It also indicates that a significant variation was found due to treatments for the dark meat ($S = < 0.005$), but no significant difference due to storage ($S = 0.82$). A significant difference due to treatment ($S = 0.008$) and no significant difference due to storage ($S = 0.36$), was also found for light meat. Therefore, the taste panel judges, in their evaluation of quality, did not distinguish a

Table 14. Three-way analysis of variance for dark and light chicken meat samples comparing taste panel evaluations by panel members, treatments and storage times

Source of variation	D.F.	Sum of squares	Mean square	F	S
<u>Dark Meat</u>					
Panel members	19	244.464	12.866	7.646	<0.005
Treatments	6	44.696	7.449	4.427	<0.005
Storage times	3	1.607	0.536	0.318	0.814
Treatment-st. time	18	35.818	1.999	1.183	0.217
Error	513	863.236	1.683		
<u>Light Meat</u>					
Panel members	19	180.877	9.520	5.376	<0.005
Treatments	6	31.068	5.178	2.934	0.008
Storage times	3	5.763	1.921	1.085	0.356
Treatment-st. time	18	67.375	3.743	2.114	0.005
Error	513	908.473	1.771		

significant difference in samples due to storage in an unfrozen or frozen state for either the dark or light meat rolls.

Quality Characteristics

Table 15 lists the average panel values for each meat characteristic, in ascending order and indicates significant differences (1% level). Dark meat rated lowest in smoke intensity and highest in juiciness. The average values for smoke intensity and tenderness of dark meat were not significantly different (1% level).

Table 15. Average panel evaluation ratings of four quality characteristics, for dark and light chicken meat samples, for all treatments and storage intervals

	Quality characteristics			
	Smoke intensity	Tender-ness	Overall desirability	Juiciness
	Average score			
	3.88	4.03	4.27	4.50
<u>Dark Meat</u> significance at 1% level	_____	_____	_____	_____
	Quality characteristics			
	Smoke intensity	Juiciness	Overall desirability	Tender-ness
	Average score			
	3.74	4.27	4.71	5.17
<u>Light Meat</u> significance at 1% level	_____	_____	_____	_____

The average smoke intensity score of light meat was slightly lower than for dark meat. Tenderness of light meat received the highest point rating, compared with juiciness for the dark. Table 15 indicates that all of the values for light meat were different (1% level).

Although light meat contained more moisture than dark meat (Table 2), panel juiciness scores averaged higher in the dark than the light samples. Possibly the higher fat content in the dark meat (Table 13) influenced this higher juiciness rating. The relationship between moisture and

juiciness is not clear-cut and the interaction with other factors may be more important.

Average tenderness scores of light meat were higher than all other scores. The tenderness quality of meat was reported by Cover et al. (1962) as more than a simple one-component system, and that juiciness appeared to be related positively to tenderness in some instances but negatively in others. Because tenderness is considered so important in consumer acceptability of meat products (Pearson 1963), it is useful to study its relationship to other quality characteristics. The Kramer Shear Press results (Table 9) indicated that, on the average, light meat was more tender than dark meat. This is in agreement with the taste panel evaluation of tenderness. In summary, tenderness did appear to be important in the overall acceptability of both dark and light chicken rolls.

Evaluation of Treatments by Overall Desirability

Table 16 ranks the average panel scores for overall desirability as influenced by treatment. This analysis combines all storage times, and isolates the influence of treatments on overall taste panel acceptability. Overall desirability represents the most important index of preference for the smoke flavor processes studied. Dark meat products soaked in the liquid smoke and curing solution received the lowest average score, while the oil base and cure application received the highest score. No significant differences

Table 16. Average taste panel scores for the overall desirability of dark and light chicken meat samples by treatments at all storage intervals^a

Treatments						
Soaking	Dipping	Dry smoke	Control	Smokehouse	Oil base	Oil base and cure
Average scores ^b						
3.84	4.01	4.15	4.16	4.51	4.56	4.64
<u>Dark Meat</u>						
significance						
at 5% level						
Treatments						
Soaking	Dipping	Dry smoke	Oil base and cure	Control	Oil base	Smokehouse
Average scores ^b						
4.31	4.51	4.54	4.83	4.85	4.94	4.99
<u>Light Meat</u>						
significance						
at 5% level						

^aDuncan's Multiple Range Test.

^bAverage scores based on 1- to 7-point scale using only the overall desirability ratings of treatments by taste panel evaluations.

were found (5% level) among the oil base and cure (highest), oil base, or smokehouse treatments for the dark meat.

Every light meat sample received a higher average overall desirability score than did the comparable dark meat sample. Even though the ratings for the dry smoke samples were not significantly different (5% level) from the four highest treatments, it seemed to be more closely associated with the two lowest rated treatments.

In summary, the products prepared by the smokehouse, oil base and oil base and cure treatments were more desirable than those prepared by soaking, dipping and dry smoking. Furthermore, every light meat treatment was more desirable, on the average, than every dark meat treatment. Although a direct taste panel comparison of light vs dark meat was not made, it is safe to conclude that the panel preferred the light meat rolls.

Simple Correlations of Quality Characteristics

Correlation coefficients are a measurement of the mutual relationship between two variables, or the degree of closeness of the linear relationships between these variables (Snedecor and Cochran 1967). Because of the large number of taste panel observations, the correlation coefficients in Table 17 are significant (1% level). However, when the correlation coefficients are less than ± 0.50 , only a minor portion of the variance of one factor can be attributed to its linear regression of the other (Snedecor and Cochran

Table 17. Simple correlations of combined taste panel evaluations of dark and light chicken meat samples, for the quality characteristics of smoke intensity, juiciness, tenderness and overall desirability at all storage times

	Quality characteristics			
	Smoke intensity (1)	Juiciness (2)	Tenderness (3)	Overall desirability (4)
Coefficients				
<u>Dark Meat</u>				
(1)	1.00			
(2)	0.06	1.00		
(3)	-0.04	0.60	1.00	
(4)	0.03	0.50	0.62	1.00
<u>Light Meat</u>				
(1)	1.00			
(2)	0.09	1.00		
(3)	-0.05	0.42	1.00	
(4)	-0.21	0.21	0.24	1.00

1967). Therefore, convincing evidence of an association, even though close, does not prove that one factor is the cause of the variation in the other. This evidence must come from other sources of analysis (Snedecor and Cochran 1967). Correlation coefficients can be useful tools in studying the relationships between the quality characteristics but its limitations must also be remembered.

Table 17 reports the simple correlations between the four quality characteristics evaluated by the taste panel for dark and light chicken rolls. The correlations were based on combined scores for all storage times.

The highest correlation coefficient for dark meat was 0.62, between tenderness and overall desirability. Other important relationships were between juiciness and tenderness (0.60), and juiciness and overall desirability (0.50).

The highest coefficient of correlation for the light meat was 0.42, between tenderness and juiciness. The correlation between overall desirability and tenderness was only 0.24, and between overall desirability and juiciness only 0.27. A negative correlation between smoke intensity and overall desirability scores (-0.21) was found in light meat only. This relationship suggests some preference for lower smoke intensity, but the low coefficient value makes it less meaningful. In general, the light meat had considerably lower coefficients of correlations than did the dark meat.

Multiple Correlations of Quality Characteristics

Table 18 presents equations which quantify the relationships of overall desirability of dark and light meat to smoke intensity, juiciness, and tenderness by a multiple correlation analysis of taste panel scores. Table 19 shows that both the dark and light meat equations, used for predicting the desirability score given the three other characteristics, are significant (0.5% level). Therefore, it is possible to analytically postulate the influence of each of the three quality variables on the overall desirability rating of the samples. The coefficient of smoke intensity

Table 18. Equations for predicting the overall desirability rating of a given sample, if the scores^a for smoke intensity, juiciness, and tenderness are known, for dark and light chicken meat samples at all storage periods

Quality Characteristics				
Overall Desirability	=	Smoke Intensity	+ Juiciness + Tenderness + Constant	
Coefficients				
Dark Meat		0.03	0.24	0.52
Light Meat		-0.16	0.27	0.17
				0.93
				3.29

^aScores were obtained from combined taste panel analyses.

Table 19. Analysis of variance for multiple correlation of quality characteristics evaluated by taste panels for dark and light chicken meat samples at all storage intervals

Source of variation	D.F.	Sum of squares	Mean square	F	S
<u>Dark Meat</u>					
Regression	3	481.484	160.495	126.06	0.005
Error	556	707.871	1.273		
<u>Light Meat</u>					
Regression	3	166.914	55.638	30.13	0.005
Error	556	1026.641	1.846		

of the dark meat was extremely low (0.03), the juiciness coefficient was relatively low (0.24), but the tenderness coefficient was fairly high (0.52).

The light meat generally had lower coefficients than the dark meat. However, the smoke intensity characteristic

had a coefficient of -0.16 , or a small negative influence on the overall desirability rating. The juiciness coefficient of 0.27 was very similar to that for dark meat, but the coefficient of tenderness (0.17) was only about one-third as large as that observed in the dark meat. The constant term was also much higher for the light meat (3.29).

Correlation Coefficients Between Objective and Subjective Analyses

Combining the information from the objective and subjective analyses is very useful in studying their influence on the acceptability of the samples. Tables 20 and 21 report the coefficients of correlation for the relationships between the subjective and objective measurements of quality.

The coefficient of correlation between tenderness (panel) and Kramer Shear maximum force was -0.63 for dark meat and -0.26 for light meat (Table 20). The negative values would be expected because the higher the Kramer Shear reading the less tender the product, while the higher the taste panel tenderness score, the more tender the product. This value for dark meat was similar to that reported by Burrill et al. (1962) in which the correlation coefficient between taste panel scores and Kramer Shear maximum force in beef was -0.72 . The coefficients of correlation between juiciness scores and Kramer Shear values were -0.64 for dark, but only 0.20 for light meat. Although the importance of this relationship is difficult to determine, the correlation

Table 20. Correlation coefficients of objective^a and subjective^b analyses of quality characteristics for dark and light chicken meat samples for combined treatments and storage periods

Quality characteristics						
Smoke intensity (1)	Juiciness (2)	Tenderness (3)	Overall desirability (4)	Kramer Shear Press (5)	% Storage yield (6)	% Moisture (7)
Coefficients						
<u>Dark Meat</u>						
(1)	1.00					
(2)	-0.23	1.00				
(3)	-0.66	0.58	1.00			
(4)	-0.23	0.34	0.54	1.00		
(5)	0.48	-0.64	-0.63	0.16	1.00	
(6)	0.20	-0.40	-0.08	0.17	0.16	1.00
(7)	-0.61	0.37	0.34	-0.33	-0.46	1.00
<u>Light Meat</u>						
(1)	1.00					
(2)	0.22	1.00				
(3)	-0.45	0.23	1.00			
(4)	-0.39	0.35	0.54	1.00		
(5)	0.48	0.20	-0.26	-0.13	1.00	
(6)	-0.20	-0.10	0.05	-0.06	-0.16	1.00
(7)	-0.59	-0.04	0.37	-0.56	0.22	1.00

^aObjective values include the Kramer Shear Press, % storage yield, and % moisture.

^bSubjective analysis includes the taste panel evaluations of smoke intensity, juiciness, tenderness, and overall desirability.

Table 21. Correlation coefficients for objective^a and subjective^b analyses of quality characteristics for dark and light chicken meat samples for combined treatments at all storage intervals

	Quality Characteristics			
	Smoke intensity	Juiciness	Tenderness	Overall Desirability
	Coefficients			
<u>Dark Meat</u>				
Peroxide value	-0.15	0.36	0.39	-0.02
% fat	0.06	0.18	-0.20	-0.51
<u>Light Meat</u>				
Peroxide value	-0.37	-0.54	-0.14	0.35
% fat	0.18	-0.44	-0.14	-0.69

^aObjective quality characteristics--peroxide value, and % fat.

^bSubjective quality characteristics--smoke intensity, juiciness, tenderness and overall desirability.

coefficients for smoke intensity evaluations and Kramer Shear values were the same and relatively high for both dark and light meat (0.48). Low coefficients were obtained between Kramer Shear readings and overall desirability scores for both dark (-0.33) and light meat (-0.13), but the fact that they are both negative supports the position that tenderness was important in acceptability.

Table 20 shows that high negative coefficients of correlation were found between percent moisture in the samples and smoke intensity scores for both dark (-0.61) and light meat (-0.59). This implies that the higher moisture content was associated with lower smoke intensity. However,

this would be expected because the control samples had relatively high moisture percentages but did not receive smoke flavoring. The correlations between percent moisture and tenderness evaluations were very similar for both dark and light meat, 0.34 and 0.37, respectively. Rather small correlation coefficients were obtained between percent moisture and juiciness or overall desirability.

The correlation coefficient between peroxide values and juiciness scores were 0.36 and -0.54 for the dark meat and the light meat samples, respectively. The correlation coefficient between peroxide values and overall desirability scores was very low for dark meat (-0.02) and only 0.35 for light meat. This supports the belief that oxidative rancidity did not affect the taste panel scores of acceptability for either the light or dark meat samples. Other correlations with peroxide values were low, but in every case the dark meat samples had opposite signs from the light meat. No apparent explanation can be given for this.

The percent fat when correlated with juiciness ratings (Table 21), gave coefficients of 0.18 for dark meat and -0.44 for light meat. The negative correlation of percent fat with juiciness scores for the light meat samples was not anticipated. The relationship of percent fat to overall desirability evaluations gave rather high coefficients of -0.51 for dark meat, and -0.69 for light meat. This would imply an unfavorable association of fat with acceptability.

Because the dark meat had a relatively high percent fat (Table 13) it is understandable that this negative relationship would exist. However, it is not as clear why the light meat should also have a high negative coefficient of correlation.

In summary, the comparisons of objective and subjective analyses provide useful information about the product quality. Some good correlations were obtained for dark and/or light meat such as: Kramer Shear vs tenderness or juiciness scores; percent moisture vs smoke intensity or tenderness scores; peroxide values vs juiciness scores and percent fat vs overall desirability or juiciness ratings.

This type of analysis presents good information for studying product quality and acceptability. However, it should be emphasized that the more influential of the two approaches is still the subjective quality evaluations. The objective methods, at best, are designed to predict eventual subjective judgments in acceptable quality.

SUMMARY AND CONCLUSIONS

Boned Leghorn fowl meat was obtained from a single flock to minimize product variation. The dark and light pieces of meat were combined with other ingredients and placed in elastic stockinette to make 42 light and 42 dark 2 lb chicken meat rolls. Six different smoke flavor treatments were applied to six rolls of light and six of dark meat, with six samples serving as controls for each. The smoke flavor treatments were designed to produce mild, smoke flavored products and included: soaking in a liquid smoke brine, dipping in a concentrated liquid smoke, regular smoke-house, oil base smoke, oil base and cure smoke, dry smoke and control (no smoke flavoring). The rolls were stored unfrozen for 1, 7 and 14 days and frozen for 21, 28 and 35 days after processing.

The dark and light meat rolls were evaluated separately by objective and subjective analyses. These evaluations included total bacteria counts, moisture analyses, cooking yields, peroxide values, Kramer Shear Press values, binding properties, and panel acceptability. The data were statistically analyzed and correlated.

Total bacteria counts were very low throughout storage, and therefore did not affect the quality. The light

meat contained more moisture, on the average, than did the dark meat, and the uncured samples significantly more than the cured.

Comparatively good cooking yields were obtained and the light meat had higher yields than the dark meat. These favorable results could be attributed to the addition of polyphosphates, the addition of soy protein concentrate in the light meat, low cooking temperature and the aluminum foil wrap.

The peroxide values were calculated to measure oxidative rancidity. Even though the peroxide values generally increased with storage time, there was little evidence that any detectable level of oxidative rancidity was present. The presence of polyphosphates and relatively short storage times could account for these minor changes. Also, the dark meat contained more than twice as much fat as the light meat.

The Kramer Shear tests indicated that light meat was more tender than dark meat, and the uncured meat was more tender than the cured. No significant differences in tenderness were found between the products which had been frozen and those unfrozen.

Both the light and dark meat rolls exhibited good binding qualities, but the light meat was definitely superior to the dark meat. This better binding of light meat could be attributed to the higher percentage of protein. The good binding observed in both dark and light meat resulted from a combination of salt solubilization of

protein, cutting the meat across the muscle to increase the surface area, addition of polyphosphates and use of elastic stockinette to effect good meat contact.

Significant differences were obtained by the taste panel between: panel members, treatments, type of meat and quality characteristics. No significant differences were caused by storage conditions. Juiciness of dark meat received the highest average rating of the four quality characteristics, and tenderness was highest for light meat. The light meat received a higher average overall desirability rating than did the dark meat.

The highest coefficient of correlation, among taste panel scores, was between tenderness and overall desirability of dark meat, and between tenderness and juiciness of light meat. Generally the dark meat had higher coefficients of correlation than the light meat. A good correlation was found between Kramer Shear values (objective) and tenderness scores (subjective) for dark meat. Other good correlation coefficients obtained for dark and/or light meat were: Kramer Shear test vs juiciness scores; percent moisture vs smoke intensity, and tenderness; peroxide values vs juiciness ratings; and percent fat vs overall desirability and juiciness evaluations.

The chicken rolls which received the oil base, smoke-house and oil base and cure treatments were rated higher in overall desirability by the panels than were the products

treated by soaking, dipping and dry smoking. Furthermore, the light meat samples rated higher in overall desirability, on the average, than did the dark meat samples from the same smoke flavor treatment.

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