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THE UNIVERSITY OF ALBERTA

EATING QUALITY OF BROILER CHICKENS FED RAPESEED MEAL RATIONS

by

© CAROL DIANE STEEDMAN

A THESIS

SUBMITTED TO THE FACULTY OF GRADUATE STUDIES AND RESEARCH

IN PARTIAL FULFILLMENT OF THE REQUIREMENTS FOR THE DEGREE

OF MASTER OF SCIENCE

IN

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FACULTY OF GRADUATE STUDIES AND RESEARCH

The undersigned certify that they have read, and recommend to the Faculty of Graduate Studies and Research, for acceptance, a thesis entitled "Eating Quality of Broiler Chickens Fed Rapeseed Meal Rations", submitted by Carol Diane Steedman in partial fulfilment of the requirements for the degree of Master of Science in Foods.

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Supervisor

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Date: .....

ABSTRACT

Broiler chickens were fed four rations: SBM, a soybean meal control ration; SBMF, a soybean meal ration with a higher fiber and fat content; RSM, a 15% Span rapeseed meal ration; and RSMHM, a 15% Span rapeseed meal with 5% herring meal, 0.1% DL methionine and 0.05% choline chloride. At 8 weeks of age, the chickens from each ration treatment were commercially killed, eviscerated and assigned to one of three storage treatments: fresh, short frozen storage (18 days) or long frozen storage (6 months).

Broilers fed the RSM ration had lower ($P < 0.05$) initial raw and cooked weights than comparable chickens fed the SBM and RSMHM rations. The initial raw and cooked weights of chickens fed the RSMHM ration were similar to the weights of chickens on the SBM ration. The thaw loss of larger chickens (RSMHM ration) was lower than the thaw loss of smaller chickens (RSM ration). Total cooking and volatile losses for SBM broilers were significantly lower than the losses for comparable chickens on the other rations. Drip loss, pH of broth and cooked meat, percentage total moisture, percentage ether extract, monocarbonyls, shear force for light and dark meat and water holding capacity were not significantly affected by ration treatment. TBA numbers for chickens fed each of the rations differed significantly.

The odor, flavor and overall acceptability scores given by trained panelists for light meat, dark meat and broth

samples were lower ($P < 0.05$) for chickens fed the RSMHM ration than the scores for comparable chickens fed the SBM, SBMF and RSM rations. Feeding the RSM ration to chickens resulted in significantly lower flavor scores for dark meat and broth, and a lower ($P < 0.05$) overall acceptability score for dark meat than the scores assigned to comparable samples obtained from chickens fed the SBM ration. There were no significant differences in juiciness attributable to ration. Tenderness scores for light and dark meat from chickens fed the RSMHM ration were lower ($P < 0.05$) than tenderness scores for comparable samples from SBM chickens.

A consumer panel assigned significantly lower odor, flavor and acceptability scores to chickens fed the RSMHM ration than to chickens fed either the SBM or RSM rations. Chickens representing the RSM ration received slightly lower palatability scores than SBM chickens. Preference ratings indicate that chickens fed the RSMHM ration were rated as "least preferred" more frequently ($P < 0.05$) than chickens fed either the SBM or RSM rations, which received similar ratings.

Storage treatment did not significantly affect initial raw weight, cooked weight, cooking losses (total, volatile and drip), pH of broth and cooked meat, total moisture (%), ether extract (%), monocarbonyls and shear force for dark meat samples. Thaw loss for chickens frozen and stored 18 days was lower ($P < 0.05$) than the thaw loss for frozen chickens, stored 6 months. The TBA number for chickens

held frozen for 6 months was lower ($P < 0.05$) than the TBA numbers for fresh chickens and frozen chickens stored 18 days. Light meat cores from chickens held frozen for 6 months required less ($P < 0.05$) shear force than comparable cores from chickens assigned to the other two storage treatments. Water holding capacity of frozen chickens stored 6 months was lower ($P < 0.05$) than water holding capacity of fresh chickens.

Generally, trained panelists indicated that broiler eating quality was not influenced by frozen storage. Odor scores for light meat from frozen chickens were significantly lower than comparable samples from fresh chickens. Dark meat from chicken frozen and stored 18 days received a lower ($P < 0.05$) odor score than dark meat from chickens held frozen for 6 months. The odor score for broth from chickens frozen and stored 6 months was lower ($P < 0.05$) than the odor score for broths prepared from fresh chickens.

Data for the combined effects of ration and storage indicate that short and long frozen storage does not affect the eating quality of chickens fed the SBM, SBMF and RSM rations. However, odor scores for light meat and broth samples from chickens fed the RSMHM ration were adversely affected when chickens were frozen and stored for 6 months.

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INTRODUCTION

Currently, soybean meal is the main vegetable protein used in rations for poultry in major poultry producing areas of the world. However, the increasing scarcity and high price of protein ingredients for poultry and animal feeding necessitate consideration of the suitability of other sources of protein in ration formulations. Canada is the world's largest producer of rapeseed (Downey et al., 1974). In addition to being economic to produce in this country, rapeseed provides an excellent source of protein. Thus, commercial feed mixes in Canada include rapeseed meal as a protein supplement to the 15% level in rations for broiler chickens.

Although many studies have investigated the nutritive value of rapeseed meal and the performance of broilers raised on rapeseed meal (Clandinin and Robblee, 1970; Clandinin et al., 1972 a; Clandinin et al., 1972 b; Leslie and Summers, 1975) there is very little published information regarding the eating quality of broilers fed rapeseed meal rations. The major purpose of this project was to evaluate the eating quality characteristics of chickens raised on a commercial ration containing rapeseed meal using objective measurements and subjective evaluations by a trained panel and a consumer panel. In order to investigate the effects of a high level of methyl groups in the ration on the eating quality of broilers, a ration containing rapeseed meal, herring meal, methionine and choline chloride was also in-

included. Chickens fed soybean meal rations served as controls.

Much of the chicken marketed to the consumer is in the frozen state. In addition, chicken is purchased fresh, frozen at home and stored until used. The length of home storage time for frozen poultry may vary from one week or less to six months or more. Generally, a frozen storage period of 6 months is considered to yield a product of optimum quality. One year is the maximum period of frozen storage recommended in order to insure good quality (Tressler and Evers, 1957; Simpson, 1962; Palmer, 1972). Research is required to evaluate the effects of short and long frozen storage periods, currently utilized by consumers, on the eating quality of chicken meat from broilers. Therefore, in this study three storage periods were included to provide information on the palatability of broiler chickens fed typical commercial rations.

LITERATURE REVIEW

Factors recognized as influencing the eating quality and acceptability of poultry include tenderness, juiciness and typical poultry odor and flavor. Perhaps one of the most important criteria influencing the consumer's satisfaction with the eating quality of broilers is the flavor of the chicken meat. The effects of diet on the production of desirable or undesirable odors and flavors in poultry meat and eggs have been reviewed by Dawson and Bouwkamp (1969). Fishy flavor in poultry meat and eggs has long been attributed to poultry rations.

Rations With Rapeseed Meal

Although rapeseed meal is widely used in Canada as a protein supplement in broiler rations, studies of the effects of rapeseed meal rations on the eating quality of broilers are limited. Recently, Yule and McBride (1976) reported that the inclusion of rapeseed meal at the 5% level (with or without lupin meal) had no detectable effect on the color, appearance, flavor, texture and general acceptability of broiler meat when evaluated by a trained taste panel. However, Yule and McBride (1976) speculated that levels of rapeseed meal above 5% in the ration may cause off-flavors in broiler meat.

Other research conducted in Australia by Spurway (1972)

has shown that mutton obtained from sheep grazing on rapeseed crops may have "off-flavors" similar to that of boiled cabbage. Park et al. (1972) found that the meat obtained from sheep that had grazed on rape had a nauseating aroma and flavor and received significantly lower flavor scores than meat taken from sheep which fed in other pastures. Further work by Wheeler et al. (1974) confirmed the occurrence of a strong, unattractive foreign flavor in meat from sheep grazing rape, but the intensity of the flavor was not consistent. The intensity of the off-flavor was not affected by cultivar, growth stage, length of grazing period or breed or age of sheep (Wheeler et al., 1974).

Rapeseed meal has been implicated in the production of tainted eggs. Abnormalities in the odor and flavor of eggs from hens fed a diet containing 8% rapeseed meal were first reported by Vogt et al. (1969). The eggs in that study were found to have a mustard oil odor. A later study (Overfield and Elson, 1975) noted that eggs laid by hens fed diets containing either 6 or 9% rapeseed meal for 5 days had a characteristic "fishy" taint. No tainted eggs were produced following removal of rapeseed meal from the diets. Overfield and Elson (1975) also reported that as the percentage of rapeseed meal in the ration increased from 0 to 9% the incidence of egg taint increased.

Leslie et al. (1973) fed much higher levels (20%) of Echo rapeseed meal than those usually recommended for laying hens (5%) and found that the eggs laid by White Leghorn hens

were similar in odor and flavor to comparable eggs produced by chickens fed a corn-soya control ration.

Later work by Hawrysh et al. (1975) determined the effects of breed or strain of hen, level and type of rapeseed meal and the presence of a source of myrosinase in the ration on the incidence of off-odor and off-flavor in eggs. Results from those experiments indicated that scrambled eggs prepared from brown-shelled eggs laid by Rhode Island Red hens fed a diet containing 6.8% Span rapeseed meal had an off-odor and off-flavor. However, brown-shelled eggs from White Plymouth Rock pullets and white-shelled eggs laid by White Leghorn pullets had normal odor and flavor. Rations containing B. napus rapeseed meal at the 5% level and a source of myrosinase resulted in the production of "fishy" scrambled eggs from White Plymouth Rock eggs. Thus, these findings (Hawrysh et al.,1975) indicated that the production of tainted eggs is influenced by several factors including breed of hen, type of rapeseed meal and the presence of myrosinase.

Further studies by Blair et al. (1975) investigated the effect on egg quality of feeding 5 or 10% Span rapeseed meal to several strains of laying hens. No egg taint was determined when eggs from White Leghorn hens were evaluated.. However, the results of this study (Blair et al., 1975) suggest that a high proportion of some strains of hens laying brown-shelled eggs were liable to produce tainted eggs when fed diets containing low levels (5%) of

rapeseed meal. Bolton et al. (1976) found that fishy taints could also occur in white-shelled eggs of some hens of a strain of Brown Leghorns.

Egg tainting is recognized as a complex problem (Hobson-Frohock et al., 1973). Factors involved in the production of tainted eggs include type and amount of rapeseed meal (Hawrysh et al.,1975; Blair et al., 1975), the breed or strain of hen (Hawrysh et al., 1975; Bolton et al., 1976) and the individual hen within the breed (Blair et al., 1975; Bolton et al., 1976). Based on their research, Bolton et al. (1976) suggest that the production of tainted eggs is under genetic control, while Blair et al. (1975) propose that trimethylamine (TMA) metabolism in the hen is a possible key to this complex problem.

Studies in the United Kingdom by Hobson-Frohock et al. (1973) isolated TMA in the yolk of tainted eggs from a strain of hens which produced brown-shelled eggs. The eggs, described as having a "fishy" or "crabby" taint, were found to contain more than 1.0 ug TMA/g egg, whereas untainted eggs contained less than 0.1 ug TMA/g egg. Hobson-Frohock et al. (1973) observed that when TMA-hydrochloride (100 mg/day) was fed to laying hens tainted eggs were produced within 6 days. In addition, tainted eggs were produced by feeding a diet containing particular batches of rapeseed meal to selected chickens. Since the rapeseed meal contained less than 1 ug free TMA/g rapeseed meal, it would not provide an immediate source of preformed TMA.

Thus, these authors (Hobson-Frohock et al., 1973) stated that a dietary source of TMA or of TMA precursor in the ration was necessary to produce taint in eggs.

A second paper by Hobson-Frohock et al. (1975) suggests that the ability of the laying hen to metabolize TMA is involved in the production of egg taint and that this ability is probably controlled genetically. Since rapeseed meal contains a very low concentration of free TMA (Hobson-Frohock et al., 1973), this study (Hobson-Frohock et al., 1975) postulates that active rapeseed meal may contain either an inhibitor of genetically limited trimethylamine oxidase activity or an excess of a precursor to TMA production. If a defect is present in susceptible hens which prevents the oxidation of TMA to TMA-oxide, which can be excreted, the blood concentration of TMA would increase and the eggs produced could be fishy. This theory may explain the findings of Blair et al. (1975) in which only certain strains of hens and certain individuals within the strain were found to lay tainted eggs. Bolton et al. (1976) postulate that fishy tainting of the eggs from hens fed rapeseed meal was conditional on the presence of a single major autosomal semi-dominant gene in the hen.

Rations With Fish Products

Fish meals have long been considered an excellent source of protein for the growing broiler and laying hen.

However, there is some concern regarding the use of fish products in poultry rations on the production of fishy off-odors and off-flavors in the broiler meat. Early research by Carrick and Hauge (1926) found that the meat obtained from chickens fed a diet containing 2% cod liver oil had no off-flavor when tasted warm but possessed a slight abnormal flavor when tasted cold. Cruickshank (1939) observed that diets containing 2% cod liver oil and 2% cod liver oil plus 15% high grade fish meal produced chicken meat with no off-flavor, but that 2% cod liver oil plus 15% low grade fish meal caused a slight but definite fishy flavor in the dark meat. Tepper et al. (1939) found no serious off-flavors or off-odors in chickens fed diets containing 13% fish meal. Asmundson et al. (1938) reported no off-flavor in turkeys fed a ration containing 25% high grade fish meal. However, Asmundson et al. (1938) noted off-flavors in the turkeys when either 2 or 5% sardine or cod liver oil were added to the fish meal rations. Carlson et al. (1957) used a basal diet containing 5% menhaden fish meal (which contributed 0.5% fish oil) and increased the level of oil in the diet by adding varying amounts of fish oil to the ration. These researchers (Carlson et al., 1957) found that between 1 and 2% added fish oil was the critical level which resulted in fishy and off-flavors in chicken meat. In contrast, Sala and Chiarella (1963) reported no fishy flavor in broilers fed 24% anchovy meal which contributed 1.4% fish oil to the diet. Hardin et al. (1964) observed that 15% solvent

extracted fish meal in broiler diets did not produce fishy flavor in broiler meat unless 1.5% fish oil was added to bring the total dietary oil content to 1.8%. From these early studies, Fry et al. (1965) concluded that: (1) fish oil per se may exert a more serious effect on broiler flavor than oil added in the form of fish meal, (2) off-flavors become apparent when total dietary fish oils are in the range of 1.5 to 2.0%, and (3) the quality of the fish meal influences the presence of fishy flavors in broiler flesh. In fact, Fry et al. (1965) substituted 100% high quality solvent extracted anchovy fish meal for soybean meal in broiler rations without causing undesirable off-flavors in poultry meat.

Investigating the use of menhaden oil in broiler rations, Edwards and May (1965) reported that the additon of as little as 2% menhaden oil to the ration imparted off-flavor to the meat of chickens fed the ration. Further research by Holdas and May (1966) determined the effect of feeding diets containing fish oil or fish meal with an equivalent amount of oil on the flavor of broth, dark meat and skin of chickens. The results indicated that the fishy flavor in carcasses appeared after 15 days on the ration and at low levels (2.5%) of total fish oil. Levels of 1.25% or less total fish oil in the ration could be used without causing any significant fishy flavor in the chicken meat (Holdas and May, 1966).

Rojas et al. (1969) replaced soybean meal protein with various levels of Peruvian anchovy meal (ranging from 2 to 20%). Fish meal levels up to 8% caused no fishy or off-flavored chicken meat. However, levels of 10, 15 and 20% fish meal containing 0.8, 1.32 and 1.76% dietary oil, re-sepctively, were associated with fishy and off-flavored meat.

Differences in the type of fish meal and the methods of processing the fish meal may influence the development of fishy taints in poultry. Opstvedt (1971) noted that 16% solvent extracted herring meal in broiler rations caused no fish taint in chicken meat, whereas when 16% ordinary herring meal was fed to broilers, 13% of the judgements indicated fishiness. Wessels et al. (1973) found that carcasses of chickens which had received diets containing 20% solvent extracted anchovy or mackerel fish meals consistently had a chickeny flavor. However, when the diets contained either water or acid extracted fish meal, the resulting carcasses had a neutral flavor. Unextracted fish meal and the triglyceride fraction of fish oil (at the 2.0% level) in the diet produced chicken meat with a "fishy" taint.

Early research by Miller and Robisch (1969) indicated that off-flavor in chicken meat resulting from continuous feeding of 1.5 and 2.5% herring and menhaden oil to broiler chickens was correlated with the increased deposition of 20:5 ω3, 22:5 ω3, and 22:6 ω3 fatty acids in the muscle tissues.

Opstvedt (1971) also reported a correlation between the flavor quality of the chicken meat and the content of C20:5, C22:5 and C22:6 fatty acids in the meat. Apparently, a level of 2% or more of these long chain polyunsaturated fatty acids in the meat produced by feeding 12% antioxidant stabilized capelin fish meal to chickens, caused flavor deterioration. However, Opstvedt (1971) noted that when the C20:5, C22:5 and C22:6 fatty acid content in the broiler meat reached a level of about 1%, which was achieved by feeding chickens a ration with 12% stabilized fish meal plus 8% ground-nut oil, excellent flavor quality was obtained. In addition, the inclusion of 8% ground-nut oil in a diet containing 12% stabilized fish meal resulted in a change in the fatty acid composition of the tissue fats. There was a marked reduction in the content of the C20:5, C22:5 and C22:6 fatty acids and a compensatory increase in the content of the C18:1 and C18:2 fatty acids in the carcass fat. The author, Opstvedt (1971), felt that these findings provided evidence that flavor deterioration in broiler meat was closely associated to the level of fat and fatty acid composition of the ration.

More recently, Opstvedt (1974) observed that various dietary fatty acids were found at similar levels in the carcass fat of chickens. The chickeny flavor or the degree of fishy off-flavor in the broiler meat were dependent on the level of the ω3 fatty acids present in the carcass fats. Four percent of the polyenoic marine fatty acids (C20:5 +

C22:5 + C22:6) in carcass fats obtained by feeding a ration containing 15% antioxidant stabilized fish meal, gave a high degree of fishy off-flavor in the chicken meat. Lowering the level of polyenoic marine fatty acids to 1.3 to 1.4% in chicken carcasses by the addition of 8% ground-nut oil to the ration, resulted in chicken meat with no fishy off-flavor.

Atkinson et al. (1972 a) found negative correlations between the level of C20:5 fatty acid and C22:5 + C22:6 fatty acids in the chicken carcasses and the flavor scores given to meat samples, but the relationship was not statistically significant. These researchers (Atkinson et al., 1972 a) suggest that factors other than the long chain highly unsaturated fatty acids or their breakdown products are involved in taint development.

Rations With Fish Products Plus Added Amines

A number of workers (Halloran, 1972; Atkinson et al., 1972 b; Wessels et al., 1973) have evaluated the importance of certain amines or their precursors in producing off-flavors in broiler meat. Halloran (1972) reported that a diet containing TMA plus 0% fish oil produced a fishy flavor in only one out of 48 observations (2.1%). Feeding a control ration with 0.75% fish oil and no TMA produced no fishy flavor in the meat, however the skin of these broilers was designated as fishy in two out of 24 observations

(8.3%). More observations of fishiness for meat (8.3%) and skin (12.5%) resulted when TMA and 0.75% fish oil were added to the basal diet and fed to broilers. Halloran (1972) also noted that the addition of TMA, with or without 0.75% fish oil, resulted in off-flavors other than fishy, but that increasing the level of fish oil did not increase off-flavor observations in the TMA treatments. All off-flavors (i.e. including fishy flavor) were more pronounced when 0.101% TMA was included in the ration. The most frequently mentioned off-flavors (in decreasing order) were bitter, fishy, strong, fish oil and oily.

Atkinson et al. (1972 b) observed that neutral chicken flavor was produced when chickens were fed 8% stabilized fish meal (containing 9.7% total fat) in the ration, but that the addition of amines (TMA, ethanolamine (EtA), and choline chloride) or their precursors to the diets containing fish meal depressed flavor scores of the chicken in most instances. A significant decline in flavor scores resulted from the addition of amines to a ration containing fat-free fish meal (0.2% total fat). However, the addition of these amines to a diet containing no fish meal did not cause a significant drop in the flavor scores of chicken (Atkinson et al., 1972 b). The authors (Atkinson et al., 1972 b) suggest that amines cannot be solely responsible for taint development in broiler meat and that the presence of fish oil or a constituent of fish meal is needed, in addition to high levels of amines, to cause the off-flavors.

Wessels et al. (1973) found that the addition of amines (TMA, EtA, and choline) aggravated fishy taints which were produced when broilers were fed either 20% unextracted fish meal or the triglyceride fraction of the fish oil (at the 2.0% level). Chickens fed a ration containing 20% solvent extracted fish meal without amines produced meat with a consistently good chicken flavor. Unfortunately, Wessels et al. (1973) did not add amines to the ration containing 20% solvent extracted fish meal to test the effect that such an addition would have on chicken meat flavor.

Storage

According to Klose (1968) about 30% of the uncooked chicken, 80% of the turkey and almost all further processed poultry products in the United States are commercially frozen. Generally, fresh broiler chickens are frozen in the home by consumers if they are not to be cooked immediately. Preservation by freezing should have no detrimental effect if processing, packaging, freezing, storage and thawing operations are properly conducted (de Fremery and Sayre, 1968). In order to maintain original high quality, especially if poultry is to be stored longer than six months, Tressler and Evers (1957) recommended that three conditions should be satisfied: (1) the storage temperature should be very low and uniform, (2) the relative humidity should be

high, and (3) the poultry products should be well-wrapped in moisture-vapor-proof material. If storage temperature is maintained at -18° or below with minimal temperature fluctuation and the poultry is properly packaged, the product should be stable for a year and possibly two years (de Fremery and Sayre, 1968).

The ultimate consideration regarding frozen poultry is palatability and consumer acceptance. Differences in eating quality between fresh and frozen chicken have generally been small, however investigators do not agree on the effects that freezing and frozen storage have on the eating quality of poultry. Early work by Stewart et al. (1945) reported that trained panelists rated all palatability characteristics evaluated in fresh broilers slightly higher than those characteristics evaluated in chickens frozen and stored at -23° for 23 days, although the differences were not significant. However, with longer storage the scores for aroma, flavor, juiciness and tenderness for the frozen broilers decreased, and the differences between the fresh and frozen chickens became highly significant after 51 days of frozen storage. Khan and van den Berg (1967) claimed that freezing caused a small but significant loss of eating quality, although none of the frozen samples were considered unacceptable.

May and Saffle (1964) reported no significant differences in organoleptic quality between frozen and ice-packed halves of the same chicken stored up to 14 days. In fact,

mean flavor scores for white and dark meat were slightly higher for the frozen than for the ice-packed halves on eight of the ten days tested (May and Saffle, 1964). Spencer et al. (1961) observed no significant differences in flavor between fried meat samples from frozen and fresh broilers. However, in evaluating extracted broth, the taste panel found that broth from fresh chicken had significantly higher flavor intensity than the broth from comparable frozen broilers.

Several consumer studies have considered the acceptability of fresh versus frozen chicken. Mountney et al. (1960) observed that half of the consumers preferred samples of fresh chicken over samples from comparable frozen chickens stored for 3 months. When the frozen storage period was extended to 9 months, 3 out of 5 consumers preferred the fresh sample. These researchers (Mountney et al., 1960) concluded there is enough difference in the flavor of frozen chicken stored 3 and 9 months to create a slight resistance toward this product. From a rather extensive consumer survey Brant et al. (1965) indicated that over 3/4 of the consumers preferred fresh broilers to frozen broilers, although over 2/3 of these consumers subsequently froze the broilers at home. Winawer and May (1964) reported consumer reluctance in purchasing frozen chicken. However, 63% of the consumers froze chicken at home even if they planned to cook it within one or two days.

Storage and Ration

Few studies have determined the effect of various rations on the frozen storage stability of poultry. In their study Klose et al. (1951) investigated the role of dietary fat, in diets containing 5% linseed oil with or without 10% fish meal (which contributed 0.6% fish oil), on the quality of fresh and frozen, stored turkeys. Klose et al. (1951) noted that the fatty acid composition of carcass fat, which reflects the fatty acid composition of the dietary fat, plays a decisive role in the storage life of turkeys. Darrow and Essary (1955) concluded that the addition of low levels of beef tallow, hydrolyzed cottonseed fats and soybean fats to broiler diets did not increase or decrease the storage life of the poultry. The organoleptic scores for aroma, flavor and juiciness indicate that broilers which received the additional fats in the diet were comparable to controls after 6 and 9 months storage at -12.8 to -20.5° (Darrow and Essary, 1955).

Marion and Woodroof (1963) also found that the fatty acid composition of the skin, breast meat and thigh meat tended to reflect the composition of the fats included in the diet. Although the total lipid level in chicken muscle tissues is low, the authors (Marion and Woodroof, 1963) stated that the long chain polyunsaturated fatty acid composition of the muscle tissue may provide an explanation for the relative ease with which broiler meat oxidizes

during storage.

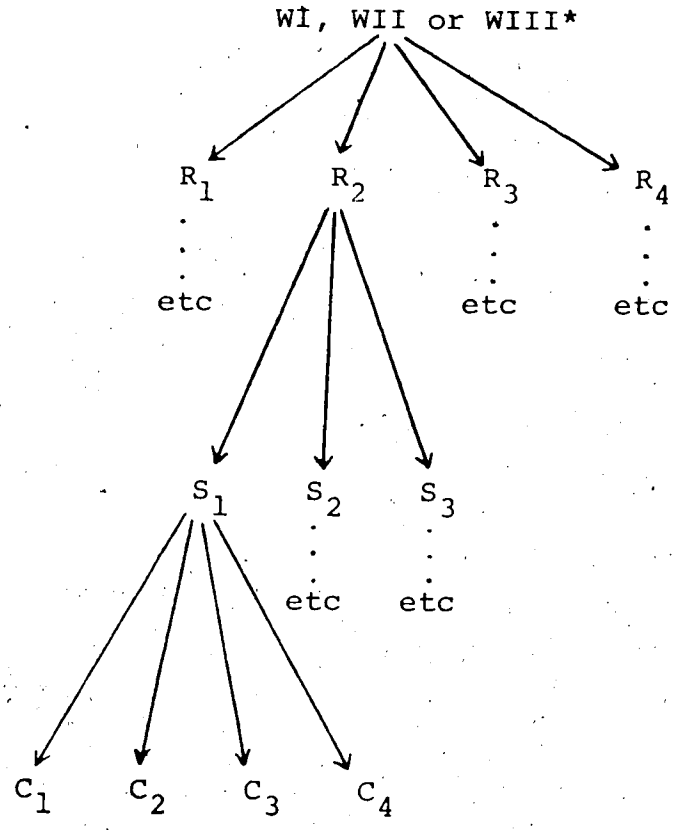
Using the TBA test, Salmon and O'Neil (1973) studied the effect of feeding diets containing 11.4% of either rapeseed oil or palm oil to turkeys on the stability of the abdominal depot fat of turkeys stored for eight months at either -12° or -22°. Neither depot fat nor thigh meat of turkeys fed either rapeseed oil or palm oil were affected by storage at -22°. However, at -12° the depot fat of turkeys fed rapeseed oil became rancid. This loss of quality at -12° was associated with higher levels of linoleic and linolenic acids in the lipid of the depot fat from turkeys fed 11.4% rapeseed oil. The stability of breast lipid was not affected by storage at either temperature (-12° or -22°). According to Salmon and O'Neil (1973), the use of unsaturated oils in poultry rations, which results in increasing unsaturation of carcass fat, will require greater emphasis on proper handling and storage.

Experimental Design and Statistical Analysis

Broiler chickens were evaluated according to a design which provided for four rations (see Table 1, page 22, for ration composition), three replications (killing times), three storage treatments (fresh, short frozen storage (18 days) and long frozen storage (6 months)), and four cooking times. Therefore for each of the four cooking times, there was one chicken per ration per killing time per storage combination.

Figure 1 summarizes the method of assigning chickens to the treatments. For each replication (WI, WII or WIII), after elimination of extremes in weight, twelve chickens of similar size were randomly chosen from the fifty chickens representing each ration. Four chickens per ration were then randomly assigned to one of the storage periods; fresh (S_1), short frozen (S_2) or long frozen (S_3) and also to one of the four cooking times (C_1, C_2, C_3 or C_4). Consequently at one cooking time, four chickens (one from each ration treatment) were cooked. This procedure was repeated for each of the three replications; therefore, fresh broiler chickens were evaluated for the three successive weeks following delivery of the chickens. Chickens frozen for a short period of time were evaluated for the next three weeks and after six months, the chickens assigned to the long frozen storage treatment were evaluated for a three week period.

Figure 1. Experimental design for assigning chickens to each treatment



* replication (killing time) repeated for three consecutive weeks

WI, WII, WIII - WI= Oct. 21, 1975; WII = Oct. 28, 1975; and WIII = Nov. 5, 1975

R_1 - Soybean meal (Control) ration (SBM)

R_2 - Soybean meal ration with high fat and fiber content (SBMF)

R_3 - Rapeseed meal ration (RSM)

R_4 - Rapeseed meal ration with herring meal, DL methionine and choline chloride (RSMHM)

S_1 - Fresh storage

S_2 - Short frozen storage (18 days)

S_3 - Long frozen storage (6 months)

C_1, C_2, C_3, C_4 - Time of cooking of 4 chickens from each of the 4 rations within each killing by storage combination.

Data were analyzed using analyses of variance. Sources of variation were ration (n=4), replication or killing time (n=3), storage (n=3), cooking time (n=4) and for taste panel data, panelists (n=6). The design of the experiment, described earlier, was a split-plot with whole units consisting of the twelve ration by killing time combinations. Sub-units consisted of storage periods and in taste panel studies the units within storage sub-units were panelists (ie. sub-sub-units). Means within significant sources of variation were compared using Duncan's New Multiple Range Test at $P < 0.05$ (Steel and Torrie, 1960).

Chickens Used for the Study

Three trials, involving 200 broiler chickens in each, were conducted. For each trial, White Mountain-Hubbard chicks were hatched weekly for three consecutive weeks at the University of Alberta farm. After each hatching, duplicate lots of 25 one-day old male chicks were placed on one of two experimental rations containing either 15% Span rapeseed meal (RSM), or 15% Span RSM, 5% herring meal, 0.1% DL methionine and 0.05% choline chloride (RSMHM). The latter ration was devised to provide a high level of methyl groups. A 28% soybean meal (SBM) control ration and a control ration containing a high fiber and fat content (SBMF) were also included. The SBMF ration was included to provide a fiber and fat content similar to that of the RSM

Table 1. Composition of the rations fed to broiler chickens.

	Rations			
	SBM[1]	SBMF[2]	RSM[3]	RSMHM[4]
Ground wheat (13% protein)	62	51.95	53.45	55.05
Wheat shorts	1.67	0.17	0.17	1.97
Stabilized fat	3	6.3	6.3	6.3
Dehydrated alfalfa meal (17% protein)	1	1	1	1
Soybean meal (48.5% protein)	28	31.25	19.75	11.15
Rapeseed meal (36% protein)	-	-	15	15
Herring meal (75% protein)	-	-	-	5
Solka-floc	-	5	-	-
Ground limestone	1.5	1.5	1.5	1.5
Calcium phosphate	1.75	1.75	1.75	1.75
Iodized salt	0.25	0.25	0.25	0.25
Manganese oxide	0.02	0.02	0.02	0.02
Zinc oxide	0.01	0.01	0.01	0.01
A-D premix*	0.25	0.25	0.25	0.25
Broiler vitamin mix*	0.5	0.5	0.5	0.5
Amprol	0.05	0.05	0.05	0.05
DL Methionine	-	-	-	0.1
50% Choline chloride	-	-	-	0.1

[1]Soybean meal (control) ration
[2]Soybean meal ration - high fat, high fiber content
[3]Rapeseed meal ration
[4]Rapeseed meal and herring meal ration with added methyl groups

*Supplied the following levels per kilogram of ration: Vitamin A, 3000 I.U.; Vitamin D_3, 600 I.C.U.; Vitamin E, 10 I.U.; Vitamin K, 1 mg; Riboflavin, 4 mg; Calcium pantothenate, 5 mg; Niacin, 20 mg; Choline chloride, 60 mg; Folic acid, 1 mg; Vitamin B_{12}, 10 mcg; and DL methionine, 227 mg.

ration. The exact composition of each ration treatment is shown in Table 1. All rations were kept isocaloric and isonitrogenous. The diets were fed to the chickens ad libitum for eight weeks. All broilers were maintained under similar housing and management conditions.

Treatment of the Chickens for Laboratory Work

After eight weeks on the rations, the broiler chickens were commercially killed, eviscerated, chilled and delivered to the Home Economics Building, University of [illegible]ta. The chickens were then refrigerated (2°) for 24 hour[illegible]velve undamaged chickens (six from each lot) were selected randomly from each ration. The chickens were washed carefully and drained prior to random assignment to one of the three storage periods; fresh, short frozen storage (18 days), or long frozen storage (6 months). Chickens assigned to frozen storage were weighed, vacuum packaged in Cryovac bags, sealed and labelled for identification. The packaged chickens were frozen (-32°) and stored (-29°) for later evaluation. Chickens assigned to the fresh storage period were treated in a manner similar to that described for the frozen chickens except that the fresh chickens were placed in polyethylene bags, sealed and refrigerated at 2° until used.

Prior to use, packaged frozen chickens were defrosted (on shallow, preweighed pans) for 48 hours in a refrigerator at 2°.

Cooking Procedure

Before cooking, the neck and wing tips were removed from each chicken and retained for preparation of broth. Each trimmed chicken was placed breast side up on an aluminum roasting pan (38cmX25cmX2cm) fitted with a wire rack (25cmX20cm with 1.5cm legs) (Figure 2). The internal temperature and cooking time of each chicken was monitored with two copper constantan thermocouples and a Honeywell recording potentiometer. One thermocouple was inserted into the thickest part of the left thigh muscles at a 45° angle to the femur for a distance of 3.5 $\pm$ 0.5 cm. The second thermocouple was inserted into the thickest part of the left breast (pectoralis major muscle) from the posterior end, 2.54 cm from and parallel to the keel bone for a distance of 4.0 $\pm$ 0.5 cm, following a modified method of Larmond (1975). Chickens were individually roasted in household electric ovens (Frigidaire, model RDG 3093) at 163° until an average internal temperature of 89° was reached. The positioning of the thermocouples and the internal temperature required to ensure adequate doneness were established in preliminary work.

After cooling to 50°, each cooked chicken was stripped of surface skin and external fat. The chickens were dissected and the breasts, thighs, legs and upper wings were individually wrapped in plastic wrap (Saran) and aluminum foil and stored in a refrigerator (2°) for 18 hours until

Figure 2. Positioning of thermocouples for cooking chicken.

used for subjective and objective measurements.

Preparation of Broth

The neck and wing tips trimmed from each raw chicken were used to prepare broth following a modified procedure of Pippen et al. (1954). The neck was cut into three pieces and the wing tips were cut in half at the joint. The chicken pieces were combined with an equal weight of distilled water in a stainless steel saucepan (1 quart). No seasoning was added. After the uncovered mixture had heated rapidly (high setting) to the boil, the heat was reduced to low and the saucepan covered. The broth was allowed to simmer, with occasional stirring, for 3 hours $\pm$ 10 minutes. At the end of the cooking period, the solids were discarded and the broth was strained through fine cotton cloth. Boiled hot distilled water was added to compensate for the weight of liquid lost by evaporation. The broth was then decanted into a separatory funnel (250 ml) and the fat was allowed to accumulate at the top. The aqueous layer was withdrawn into a beaker (400 ml). The beaker of broth was tightly covered with plastic wrap (Saran) and a piece of aluminum foil, and refrigerated (2°) until used (18 hours) for subjective and objective measurements. Throughout the study, precautions were taken to ensure that the same saucepans and separatory funnels were always used to prepare broths representing each ration.

Object Measurements

All objective measurements, except for thaw loss, were made on cooked meat. Sampling techniques for the objective tests were standardized during the preliminary work.

Thaw Loss

Thaw loss of frozen chickens was determined and expressed as a percentage, based on the weight of the raw chicken prior to freezing.

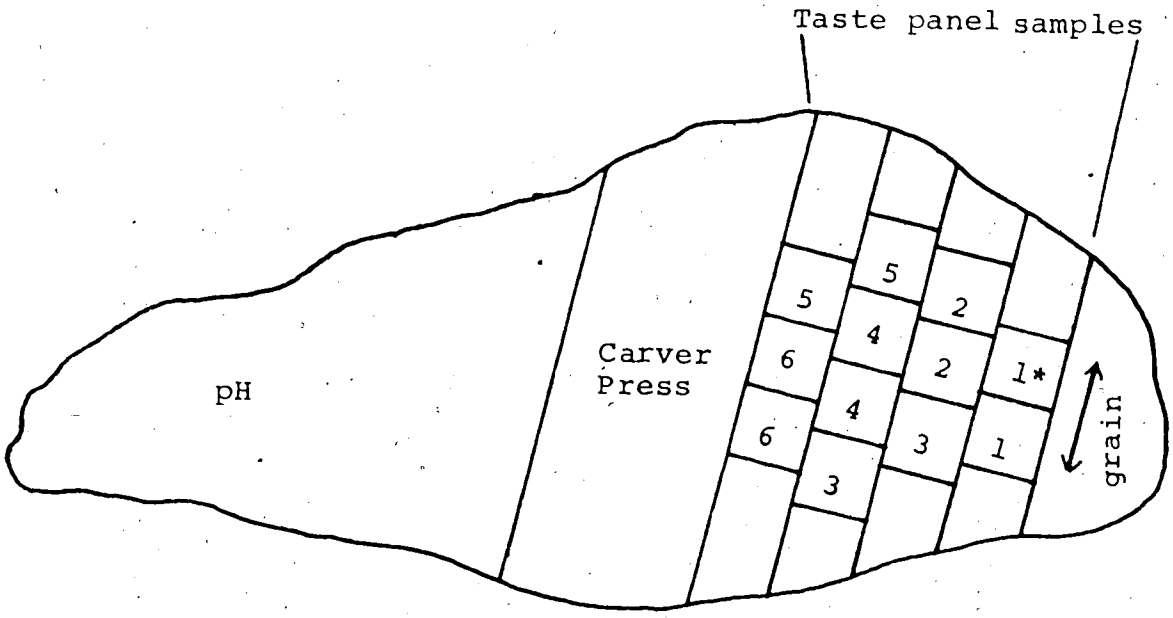
Cooking Losses

Percentage total, volatile and drip losses, based on the weight of either the fresh, trimmed chicken or defrosted, trimmed chicken, were calculated.

pH

A Fisher Accumet Model 230 pH/ion meter was used to determine the pH of the cooked light meat and the broth. For pH determinations of the light meat, a 20 gram sample was removed from the posterior end of the right breast of each chicken (Figure 3, page 29). The sample was blended with 100 ml distilled water for one minute and filtered into two beakers to give duplicate readings. The pH of the broth was determined on the broth remaining after samples were removed for the taste panel. Duplicate readings of broth pH were taken immediately before taste panel sessions.

Right Breast



* Numbers indicate sample position

Figure 3. Location of samples for objective measurements and subjective evaluation of light chicken meat.

Fat and Moisture

The percentages of fat (ether extract) and moisture were determined by the methods of the Association of Official Agricultural Chemists (AOAC, 1965). Cooked muscle tissue from the proximal portion of the wings and from the legs of each chicken were frozen and stored for 4 to 6 weeks at -29°. Immediately before testing commenced, samples were thawed (in a refrigerator (2°) for 17 hours), ground and mixed thoroughly. Percentage moisture was determined by freeze-drying each of the samples and then drying them for an additional 18 hours at 105°. A Goldfisch extraction apparatus was used to determine the percent ether extract (fat). For each replication, duplicate determinations were made on each of two chickens representing each ration by storage treatment.

Thiobarbituric Acid Values (TBA)

Thiobarbituric acid (TBA) values, for the determination of oxidative rancidity, were obtained using the method of Tarladgis et al. (1964) with the following modifications. Duplicate 5 gram samples of ground tissue (removed from the back of a designated cooked chicken) were blended with 50 ml of glass distilled water for two minutes. A second set of samples from the same chicken, was blended with $1X10^{-5}$ M 1,1,3,3-tetraethoxypropane (TEP) for percent recovery determinations. The resulting slurries were quantitatively transferred, with 50 ml glass distilled water, into funnels lined with Whatman No. 1 filter paper. The filtrates

were acidifed with hydrochloric acid and distilled on a Kjeldahl apparatus until 50 ml of distillate collected in each of two 50 ml volumetric flasks. Two 5 ml aliquots from each flask were pipetted into test tubes and 5 ml of 0.02 M 2-thiobarbituric acid in 90% glacial acetic acid was added. The test tubes were stoppered, placed in a boiling water bath for 45 minutes and then allowed to cool for 10 minutes. Absorbance was read against an appropriate reagent blank at 532 nm using a Pye Unicam SP 1800 Ultraviolet Spectrophotometer. For each replication, duplicate determinations were made on each of two chickens representing each ration by storage treatment.

Standard curves were prepared as outlined by Tarladgis et al. (1960). The TBA number was calculated by multiplying the absorbance by K constants obtained from the standard curves and the known dilutions according to Tarladgis et al. (1960).

Monocarbonyl Analyses

Monocarbonyls (mg/g fat) were determined by a modified method of Schwartz et al. (1963). Carbonyl-free hexane, (prepared as described by Hawrysh and Stine, 1973), was used to extract the fat from the cooked chicken skin and from the pan drippings resulting from cooking the chickens. Water was removed from the hexane-lipid solution by adding anhydrous granular sodium sulfate. The hexane-lipid mixture was vacuum filtered and the filtrate was centrifuged (10,000 rpm for 15 minutes). The supernatant was decanted and

duplicate samples of known volume (10 to 15 ml) were dried. After the weight of fat per ml supernatant was calculated, a volume of the hexane-lipid mixture corresponding to 8 to 10 grams of fat was added to each of a pair of duplicate 2,4-dinitrophenyl hydrazone (DNPH) reaction columns, which had been prepared as described by Schwartz et al. (1963). The column was flushed with carbonyl-free hexane until the effluent had the same spectral properties as that of the carbonyl-free hexane which had passed through the reaction column prior to sample addition. The hexane was evaporated from the solution over steam with nitrogen. The lipid material was removed from the hydrazones with a Celite 545-Sea Sorb column according to the procedure of Schwartz et al. (1963) as modified by Anderson (1966). Elution of the hydrazones from the column was effected with 175 ml of chloroform-nitromethane solution (3:1 v/v). The carbonyl solution was evaporated completely and a known volume of hexane was added to dissolve the hydrazones. The solutions passed over an activated alumina column to remove keto-glycerides and decomposition products. (Schwartz et al., 1963). Elution of the monocarbonyl fraction was effected with 70 ml benzene-hexane solution (1:1 v/v) (Schwartz and Parks, 1961). The optical density was read at 360 nm and mg monocarbonyls/gm fat was calculated using the formula of Day (1965). Duplicate determinations were made on each of three chickens taken from each ration by storage treatment combination.

Warner Bratzler Shear

Samples for Warner Bratzler shear measurements were taken from the left breast (light meat) and the left thigh (dark meat) as shown in Figures 4 and 5 . The locations used for shear measurements corresponded to the anatomical position on the right side of the chicken which was utilized for subjective evaluation.

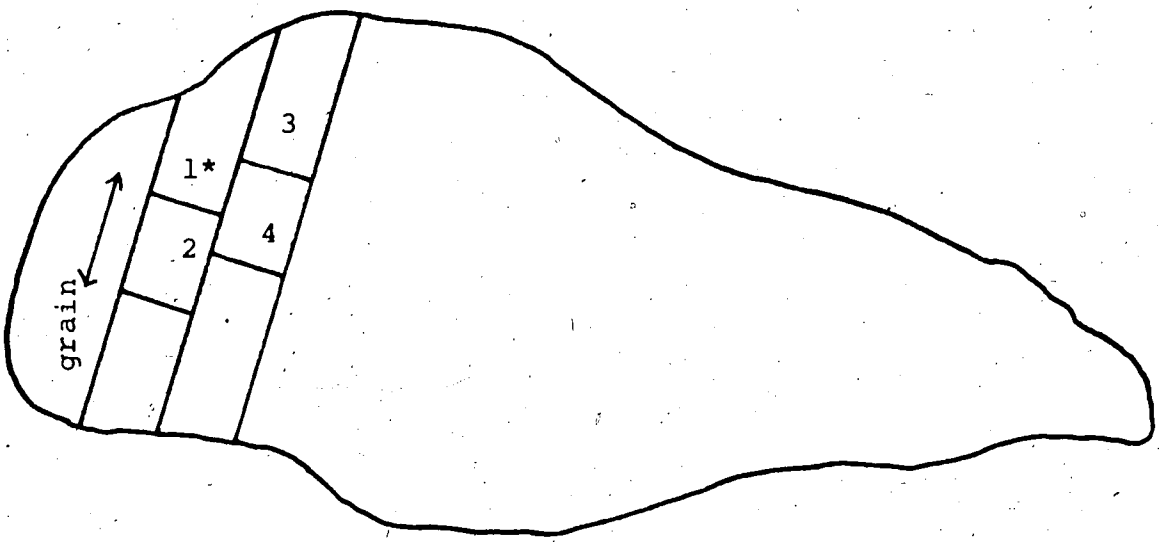
For shear measurements on light meat, two 1 cm slices cut parallel to the grain near the anterior end of the left breast were removed and trimmed to yield cores (1cm X 1cm X muscle width). Each of the cores was sheared twice at 1.3 cm intervals using a Warner Bratzler Shear Apparatus equipped with a 22.7 kg dynamometer. The overall shear value of each light meat chicken sample was the average of four shear readings.

Dark meat samples for Warner Bratzler shear measurements consisted of a composite muscle sample from the left thigh. The meat was removed from the bone according to the method utilized for subjective evaluation. A 1 cm X 1 cm core was cut down the length of the largest piece of muscle tissue (Figure 5). Four shear measurements were made at 1.3 cm intervals along the length of the core. The four readings were averaged to give an overall Warner Bratzler shear value for dark chicken meat.

Water Holding Capacity (WHC)

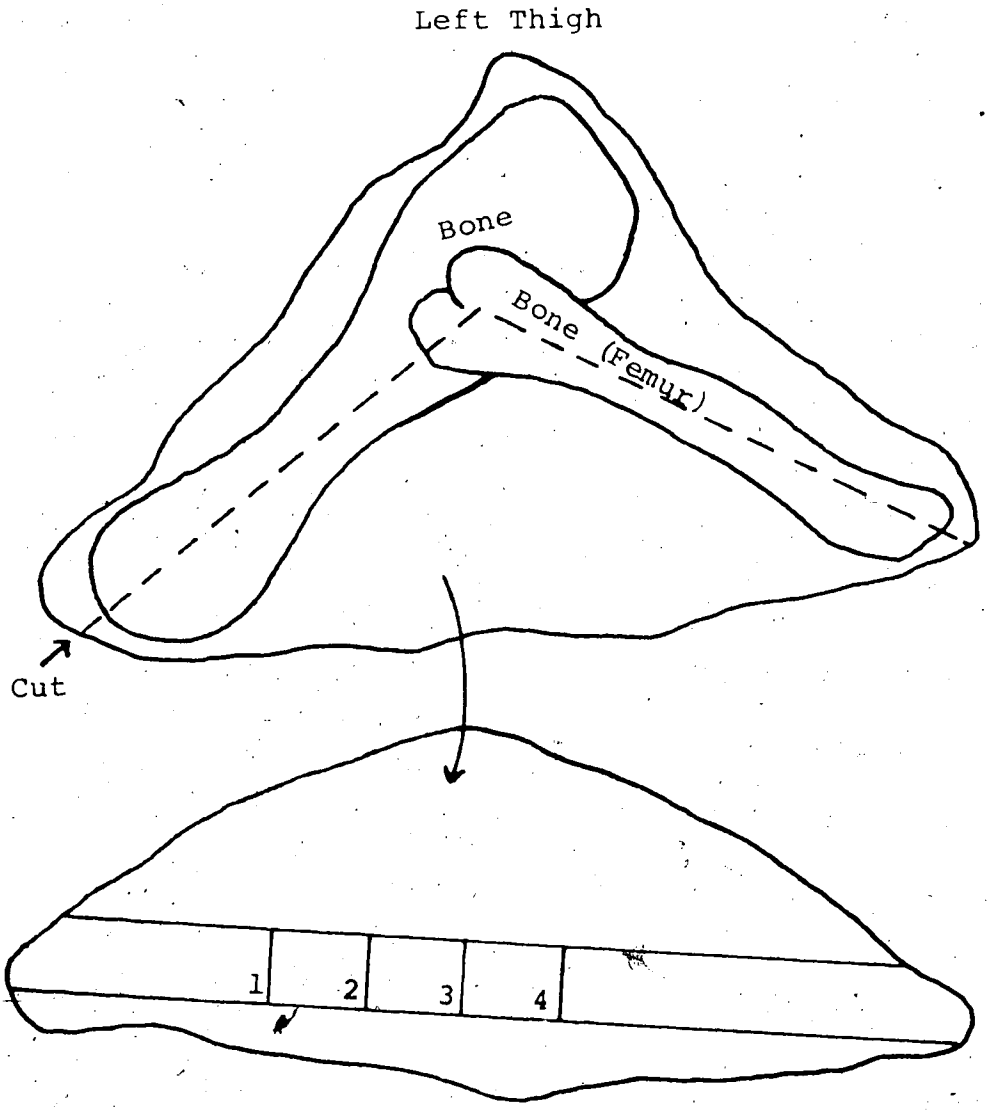
Water holding capacity (WHC) of cooked light meat samples was determined by the method of Miller and Harrison

Left Breast



* Numbers indicate shearing order.

Figure 4. Location of samples for Warner Bratzler shear measurements of light chicken meat.



* Numbers indicate shearing order.

Figure 5. Location of samples for Warner Bratzler shear measurements of dark chicken meat.

(1965), with modifications suggested by Forbes (1973). Triplicate 0.5 gram samples from the right breast of each chicken (Figure 3, page 29) were placed between a sheet of Whatman No. 1 qualitative filter paper and a piece of aluminum foil, and alternately stacked between four plexiglass plates. This unit was pressed in a Carver Laboratory Press under a total pressure of 878.8 kg/cm^2 for 30 seconds.

The area of the pressed meat and the expressed fluid were determined using a Hughes-Owens compensating planimeter (Model 349-1838). The ratio of the area of the pressed chicken meat to the area of the expressed liquid was designated as the expressible liquid index. Unity arbitrarily was assumed as the maximum expressible liquid index for any particular cooked chicken sample, and the relative WHC was 1.00 minus expressible liquid index (Miller and Harri 1965).

Subjective Evaluation by a Trained Panel

A six-member taste panel consisting of graduate students and staff members from the Faculty of Home Economics, University of Alberta, participated in the study. Panel members were selected on the basis of their ability, interest in the study and availability for the duration of the study.

Training Sessions

Training sessions for light and dark chicken meat and

broth were conducted four times per week for a seven-week period. During the training, panelists were gradually acquainted with panel procedures, definitions of terms and the types of testing techniques to be utilized. Taste panel members evaluated samples of light and dark chicken meat and broth representing the SBM, RSM and RSMHM rations, and chickens available on the commercial market. In addition, panelists were trained to distinguish differences between the odor and flavor of fresh, good quality chicken meat and broth, and the odor and flavor of "fishy" chicken meat and broth. "Fishy" or "off" samples used in the training sessions were obtained by storing pieces of cooked chicken in a closed container with herring meal, or by adding the juice of either canned crab or water-packed tuna to the broth.

Light meat and dark meat samples were evaluated for odor, flavor, juiciness, tenderness and overall acceptability on a seven-point scale, with 7 representing the highest intensity and 1 indicating the lowest intensity. Scorecards and instructions to the judges are included in the Appendix, Figures 1 and 2, pages 108 and 109. A list of descriptive terms (Appendix, Figure 3, page 111) was provided to judges to aid in the evaluation of odor and flavor. In judging the odor (initial impression) and flavor (impression after continued chewing) of the chicken meat, panelists were asked to state reasons for assigning a score of three or less. The juiciness (based on three chews) of chicken samples was evaluated using a technique in which

standard foods served as anchors (McLandress, 1972; Forbes, 1973; Smith, 1976). The food standards relating to the anchor scale for juiciness of beef (Smith, 1976) did not seem to be related to chicken, thus, judges established an anchor scale for the juiciness of both light and dark chicken meat. Garbanzo beans (El Paso brand) were rated as a "2", or dry, while dark seedless raisins (Woodward's brand) were assigned a score of "5", or juicy. At the beginning of each panel session, the anchor foods were tasted to establish a range for the intensity of juiciness of the light and dark meat samples. Each panelist standardized her tenderness scores by the number of chews required to completely masticate a one cm cube of chicken. Overall acceptability was evaluated on a desirability scale of 7 (extremely desirable) to 1 (extremely undesirable).

The odor and flavor of broth samples were evaluated using a Multiple Comparison Test. Judges scored each of the coded samples in comparison with the reference (SBM control ration) sample. The scorecard for this test is included in the Appendix, Figure 4, page 112. A descriptive five-point scale, with 5 indicating "no difference" from the reference and 1 indicating an "extreme difference" from the reference, was used for scoring. Panelists evaluated the broth samples under red lights so that any color differences in the broths that might bias the judges' evaluations were masked.

Judges were considered sufficiently trained when each panelist scored the light meat, dark meat and broth samples

consistently from day to day. A range of two points on the seven-point scale for meat samples and a range of one point on the five-point scale for broth samples was considered as a minimum variability.

To ensure the panelists' acuity, additional panel sessions were scheduled for four weeks prior to the evaluation of samples from the long storage treatment. Chickens representing the SBM, RSM and RSMHM rations were obtained from the University of Alberta farm immediately before the refresher sessions and held frozen until used.

Method of Evaluation

The six panelists each evaluated four sets of coded light meat samples, coded dark meat samples, and broth samples at each panel session ploying the techniques developed during the training period. Taste panel sessions were held at 10:45 a.m. and/or 2:15 p.m. four times per week in an air-conditioned room designed specifically for the subjective evaluation of food and equipped with individual booths. Each panelist received a tray containing the coded light meat samples (two cubes representing each ration treatment), the food standards for juiciness, the appropriate set of evaluation forms (Appendix, Figures 1 to 4, pages 108 to 112 , respectively), and other necessary items. Panelists were provided with unsalted soda crackers and water at room temperature to remove any residual aftertaste from the mouth between tasting samples. As each judge finished scoring the light meat samples, a set of warm,

coded dark meat samples was presented for evaluation. Panelists were given a short break before broth samples were distributed. A set of five teaspoons was given to panelists for scoring the broth samples.

The trays were prepared immediately before panel sessions to ensure freshness of the standards and the samples. The position of samples for light and dark meat was rotated for each judge at each panel session and the order in which the meat samples and the broth samples were presented was randomized.

Sampling Procedure for the Trained Panel

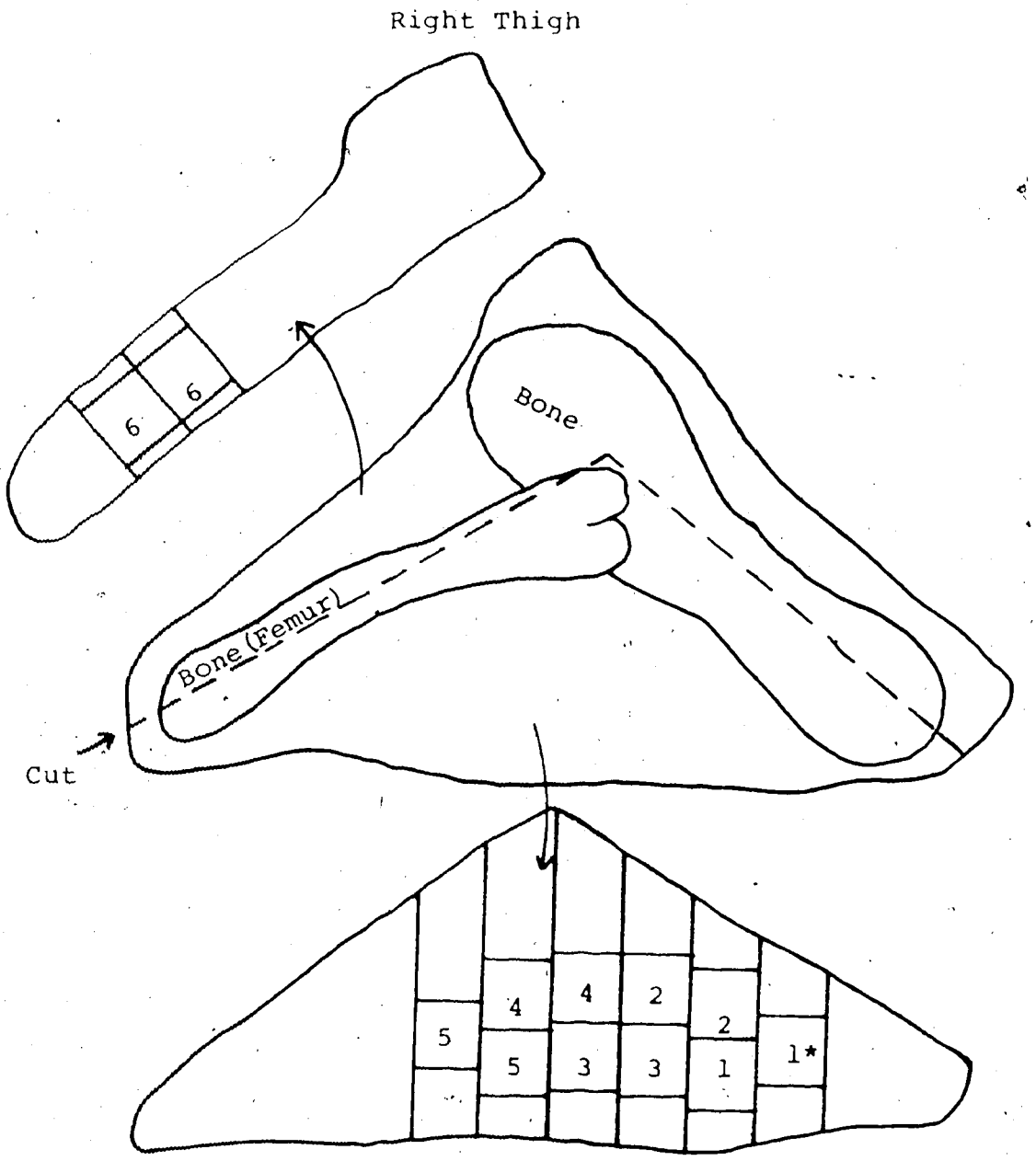
All sampling procedures were standarized during preliminary work.

1. Light Chicken Meat

The light meat from the right breast was cut into pieces as illustrated in Figure 3, page 29. The anterior (curved) end of the breast was removed following the grain of the pectoralis major muscle. Four 1 cm thick slices were c and 1 cm cubes were removed from each slice (Figure 3). Two 1 cm cubes from each ration treatment were placed on a coded plate, covered with plastic wrap (Saran) and allowed to stand 30 minutes in order to reach room temperature (22°).

2. Dark Chicken Meat

A composite muscle sample from the right thigh was used for subjective evaluation of dark meat (Figure 6). The inside portion of the thigh, including the sartorius and



* Numbers indicate sample position.

Figure 6. Location of samples for subjective evaluation of dark chicken meat.

iliotibialis muscles, was utilized for five of the six sets of samples. The sixth pair of taste panel samples was obtained from meat at the top of the femur near the proximal joint. The meat was slit along the bones and then carefully separated from the bones. The 1 cm slices, cut perpendicular to the grain of the top muscle (iliotibialis), were cut into 1 cm cubes so that a pair of cubes came from adjacent positions (Figure 6).

The cubes of dark meat representing a particular ration were placed individually in a covered casserole dish (17.5 cmX25cmX7.5cm). The dishes (containing all the samples) were subsequently set in large pyrex pans containing hot water ($65 \pm 5°$). The entire system was held for 20 minutes at low heat on a Salton Hotable Tea Cart (Model H - 156W) until the samples were evaluated by the panelists. (Modified procedure of Ferger et al., 1972). The warm samples were placed on hot coded plates and presented to each of the judges.

3. Broth

One and one half hours before evaluation, broth samples were removed from the refrigerator. Each covered broth sample was placed individually in a Corningware saucepan (1/2 quart) containing boiling water. The broth samples were warmed until they were liquified (medium heat for 10 minutes). Ten ml samples of broth were poured into coded 50 ml beakers and the beakers were covered with small watch-glasses. Prior to distribution to judges, the broth samples

were heated for 10 minutes on two Salton hottrays (Models H 120, Series E and H 920, Series P) set on low. To ensure a temperature of 55 ± 5° during evaluation, broth samples were placed in aluminum pans (20cmX20cmX4cm) filled with hot sea sand (heated in an oven at 107° for 45 minutes) and then presented to the judges.

Two broth samples prepared from chickens fed the SBM ration served as the reference sample, and a set of four broth samples from chickens fed each of the rations (SBM, SBMF, RSM and RSMHM) made up the complete set of broth samples evaluated by each judge at each panel session.

Subjective Evaluation by a Consumer Panel

Experimental Design and Statistical Analysis

The consumer evaluation of chickens was conducted using a modified procedure of Winawer and May (1964). Three District Home Economists, employed by Alberta Agriculture in three areas of Alberta (Camrose, Ponoka and Vegreville), each randomly selected 50 consumer households which were willing to participate in the study. The home economists, distributed the chicken samples and a questionnaire to the participants, acted as resource people for queries and collected the results.

The McGuire-White social class index (McGuire and White, 1955) served as a basis in developing the questionnaire (Appendix, Figure 5, page 113). The

information obtained from the questionnaire was tabulated to provide a description of the consumer population that took part in the study. The results of the consumer evaluation of the quality of the chickens and the preference ratings for broilers representing the different rations were tabulated. The data were analyzed using analyses of variance and means were tested for significance using Duncan's New Multiple Range Test (Steel and Torrie, 1960).

Chickens Used for the Consumer Study

Broiler chickens remaining after initial allotment of chickens to storage treatments for laboratory work were cleaned as described on page 23 . Each chicken was identified with double wing tags, vacuum packaged in a Cryovac bag, frozen at -32° and stored at -29° for six weeks. To avoid presenting the participants with too many samples, only chickens raised on the SBM, RSM and RSMHM rations (Table 1 , page 22) were used in the consumer study. Just before sample distribution to consumer participants, the frozen chickens were sawed in half and each chicken half was individually vacuum packaged in a Cryovac bag. Consumer packets containing three coded frozen half-chickens, a questionnaire, an instruction sheet, a scorecard (Appendix, Figures 5, 6 and 7 , pages 113 to 118) and a small information booklet[1] on chickens, were assembled.

[1]Cooking Alberta's Chicken - Alberta Broiler Growers Marketing Board Publication

Cooking Procedure

A copy of the instruction sheet given to consumers is included in the Appendix, Figure 6 , page 115. Each homemaker was instructed to defrost the chicken halves in their packaging, at either room temperature or in the refrigerator. The thawed samples were removed from their packaging and each defrosted, coded chicken-half was individually drugstore wrapped in aluminum foil. The foil-wrapped chicken halves were placed on a rack in a baking pan and cooked at 176° until done. This procedure prevented the cooking juices and odors from mingling in the oven. Participants were informed not to add any herbs or spices to the chickens, except for a small amount of salt if desired.

Method of Evaluation

Two-thirds of the participants scored the chickens according to the randomized order listed on their scorecards. One-third of the wing tags on the frozen chickens were not visible to the researcher and could not be randomized for panelist evaluation. Thus, the participants scoring these chicken halves were asked to write the code number of each chicken in the space provided on the scorecard as they scored each sample.

The participants evaluated the odor, flavor and overall acceptability of each half-chicken individually using a 5-point scale, with 5 representing the highest score. A copy of the scorecard used by the consumers for evaluation of the chickens is included in the Appendix, Figure 7 , page 118 .

After the three chicken halves had been evaluated individually, the participants ranked the samples in order of preference, with "1", representing the most preferred and "3", the least preferred sample. A space was provided for the participants to give suggestions and comments regarding the study, and to list any problems they encounter in cooking chicken.

RESULTS AND DISCUSSION

Throughout the discussion SBM refers to the soybean meal control ration; SBMF, to the soybean meal ration with a high fat and high fiber content; RSM, to the rapeseed meal ration; and RSMHM, to the rapeseed meal ration with 5% herring meal, 0.1% DL methionine and 0.05% choline chloride. Table 1, page 22 , gives the exact composition of the rations.

Ration

Objective Measurements

The data for objective measurements for chickens fed the four rations are presented in Table 2. Analysis of variance and application of Duncan's Multiple Range test (Steel and Torrie, 1960) showed that the mean percentage thaw loss for chickens raised on either the SBM or the RSMHM ration was lower ($P < 0.05$) than the thaw loss of comparable chickens fed the RSM ration. Broilers representing the SBMF ration had a mean percentage thaw loss similar to the thaw losses of the chickens from the other three ration treatments. Data for percentage thaw loss show that larger chickens (RSMHM ration) yielded a lower thaw loss than did smaller chickens (RSM ration). Because the thawing time for all chickens was constant, the higher percent-

Table 2. Means and SE[1] for objective measurements from chickens fed the four rations.

Measurements	Rations[2] SBM	SBMF	RSM	RSMHM	SE
Thaw loss (%)[3]	2.9[b]	3.3[ab]	3.6[a]	2.8[b]	.17**
Initial raw weight (g)[4]	1144.7[ab]	1112.9[bc]	1097.2[c]	1162.2[a]	11.86*
Cooked weight (g)[4]	863.8[ab]	819.6[bc]	814.6[c]	860.5[a]	11.82*
Cooking losses (%)[4]					
Total	24.5[b]	26.3[a]	25.7[a]	26.0[a]	.34*
Volatile	18.6[b]	20.7[a]	20.6[a]	20.4[a]	.26**
Dri	5.9	5.6	5.2	5.6	.25
pH[5]					
Broth	6.7	6.7	6.7	6.7	.01
Cooked meat	6.2	6.2	6.2	6.2	.01
Total moisture (%)[6]	64.8	64.5	64.2	64.4	.44
Ether extract (%)[6]	5.1	5.1	4.8	4.6	.22
TBA number[6]	6.0[d]	7.2[b]	6.4[c]	7.7[a]	.11*
Monocarbonyls (mg/g fat)[7]	.11	.17	.12	.17	.01
Shear force (kg/cm core)[8]					
Light meat	2.1	2.2	2.2	2.3	.17
Dark meat	1.1	1.0	1.2	1.1	.04
Water holding capacity[9]	.66	.63	.65	.64	.01

[1]Standard error of the means.

[2]See footnote 1-4, Table 1, page 22.

[3]Values are the means of 24 determinations, one per chicken from short or long frozen storage treatments.

[4]Values are the means of 36 determinations. (Initial raw weight - wing tips and neck removed.)

[5]Values are the means of 72 determinations, two per chicken.

[6]Values are the means of 36 determinations, two on each of six chickens per storage period.

[7]Values are the means of 18 determinations, two on each of three chickens per storage period.

[8]Values are the means of 144 determinations, four per chicken.

[9]1.0 - (expressible liquid index); the larger the value, the greater the amount of liquid expressed. Values are the means of 108 determinations, three per chicken.

[abcd]Means within the same row sharing a common superscript letter are not significantly different at $P \leq 0.05$.

*Significant at $P<0.05$.

**Significant at $P<0.01$.

age thaw loss obtained for smaller chickens is probably due to the evaporation of more moisture from defrosted chickens.

The mean initial raw and cooked weights (g) of chickens fed the RSM ration were lower ($P < 0.05$) than the initial raw and cooked weights of chickens raised on either the SBM or RSMHM rations. Chickens representing the SBMF ration had mean raw and cooked weights similar to the weights of chickens fed the RSM and SBM rations (Table 2).

Yule and McBride (1976) noted that live-weights of chickens were depressed when 5% Australian expeller rapeseed meal was included in the diet alone or in combination with 8% lupin meal. Feeding Span rapeseed meal at levels of 5.5 and 11% resulted in broilers of lower ($P < 0.05$) weights than those of comparable broilers fed a soybean meal control ration (Leeson and Summers, 1976).

In contrast, earlier work by Nakaya et al. (1968) with broilers 4 to 9 or 10 weeks of age, found little difference in body weight gain of broilers fed 10 to 20% rapeseed oilmeal and broilers fed a soybean oilmeal control ration. These results (Nakaya et al., 1968) suggested that 10 to 20% rapeseed oilmeal might replace soybean oilmeal in broiler finisher rations without adverse effects when the dietary levels of energy and protein were controlled.

In the present study, supplementation of the RSM ration with 5% herring meal, 0.1% DL methionine and 0.05%

choline chloride (RSMHM ration) resulted in broilers with weights similar to those of broilers on the SBM control diet. Feeding the RSMHM ration to broilers significantly improved broiler weights compared to the weights of comparable broilers fed the RSM ration (Table 2). These data support the results of Clandinin and Robblee (1966) who observed that up to 15% prepress-solvent and solvent extracted Canadian rapeseed meals included in rations containing 3.0% herring meal and 0.2% choline chloride produced broilers similar in weight to comparable broilers fed soybean meal rations. Energy to protein relationships must be maintained in order to keep growth promotion and feed conversion similar between the rapeseed meal ration group and the soybean meal ration group. These researchers (Clandinin and Robblee, 1966) also observed that the amino acid distribution of Canadian rapeseed meals was comparable to that of soybean meal. More recently, Clandinin et al. (1972 a) and Marangos et al. (1974) found that body weight was not influenced by the inclusion of 15% and 12% respectively, of various types of rapeseed meals in broiler rations containing herring meal.

Total cooking and volatile losses for chickens fed the SBM ration were significantly lower than the losses of comparable chickens fed the other three rations (Table 2). Drip losses for chickens representing all of the rations were similar.

There were no significant differences in pH for either

broth or cooked meat attributable to ration, although broth samples gave consistently higher pH readings (approximately 0.5 pH unit). Percentage total moisture and percentage ether extract of cooked meat were not significantly affected by ration treatment (Table 2).

TBA numbers for chickens raised on each of the four rations differed significantly ($P < 0.05$). Meat samples obtained from chickens raised on the SBM ration had the lowest TBA number; samples representing the RSM ration had the second lowest number. The TBA number of samples taken from chickens fed the SBMF ration was next, and was significantly different from the TBA number of samples representing the RSMHM ration, which had the highest TBA number.

The composition of the fatty acids in the ration influences the composition of the carcass fat of the chicken (Klose et al., 1951; Marion and Woodroof, 1963; Miller and Robisch, 1969; Atkinson et al., 1972 a). The residual oils in fish meals have high levels of certain long chain polyunsaturated fatty acids which are reflected in the fatty acid composition of the carcass (Miller and Robisch, 1969; Opstvedt, 1971; Atkinson et al., 1972 a). The oxidation level of tissue fat is known to be related to the degree of unsaturation of fatty acids in the tissue lipid. Thus, in the present study, the unsaturated fatty acids present in the residual oil of the herring meal may contribute to the high TBA number obtained for chickens fed the RSMHM ration. Webb et al. (1974) noted that the inclusion of fish meal in

the rations of turkeys resulted in an increase in TBA numbers, with numbers increasing as level of dietary fish meal increased from 0 to 10%.

Monocarbonyl analyses of the fat extracted from the chicken skin and from the pan drippings resulted in slightly higher values for chickens raised on the SBMF and RSMHM rations than those obtained for samples from comparable chickens fed [illegible] SBM or RSM rations, however the differences were [illegible]gnificant (Table 2).

Warner [illegible] shear force values for cooked light and dark meat samples showed no significant differences attributable to ration. Goodwin et al. (1969) stated that the composition of the diet had relatively little or no influence on tenderness as long as broilers were growing at the maximum rate. Water holding capacity data for meat from broilers raised on the four different rations were similar (Table 2).

Subjective Evaluation by a Trained Panel

Data for trained taste panel evaluations of light meat, dark meat and broth samples are summarized in Table 3. Taste panel evaluations of light meat samples indicate that the odor, flavor and overall acceptability scores of samples from chickens fed the RSMHM ration were lower ($P < 0.05$) than those for comparable samples from chickens raised on the SBM, SBMF and RSM rations. Panelists frequently de-

Table 3. Means and SE[1] for subjective evaluations by a trained panel for light meat, dark meat and broth samples from chickens fed the four rations.

Measurements	Rations[2] SBM	SBMF	RSM	RSMHM	SE
Light meat[3]					
Odor	4.6[a]	4.6[a]	4.6[a]	3.4[b]	.06***
Flavor	4.8[a]	4.7[a]	4.6[a]	2.7[b]	.11***
Juiciness	4.1	3.9	4.0	4.0	.37
Tenderness	5.1[a]	5.0[ab]	5.1[a]	4.8[b]	.07*
Overall acceptability	4.7[a]	4.6[a]	4.7[a]	2.7[b]	.11***
Dark meat[3]					
Odor	4.2[a]	4.1[a]	4.1[a]	2.6[b]	.05***
Flavor	4.5[a]	4.3[ab]	4.1[b]	2.1[c]	.08***
Juiciness	4.6	4.6	4.6	4.5	.05
Tenderness	5.1[a]	5.1[a]	5.0[ab]	1.9[b]	.02**
Overall acceptability	4.5[a]	4.3[ab]	4.2[b]	2.0[c]	.06***
Broth[4]					
Odor	4.4[a]	4.2[a]	4.3[a]	3.3[b]	.06***
Flavor	4.3[a]	4.0[b]	4.1[b]	2.8[c]	.06***

[1]Standard error of the means.

[2]See footnote 1-4, Table 1, page 22.

[3]Seven point scale with 7 being the highest score and 1 being the lowest score. Values are the means of 36 judgments by each of six panelists.

[4]Five point scale with 5 being "no difference" from reference sample and 1 being "extreme difference". Values are the means of 36 judgments by each of six panelists.

[abc]Means within the same row sharing a common superscript letter are not significantly different at $P \leq 0.05$.

*Significant at $P<0.05$.

**Significant at $P<0.01$.

***Significant at $P<0.001$.

scribed the odor and flavor of light meat samples from chickens fed the RSMHM ration as "fishy" or "rancid".

There were no significant differences in the juiciness of light meat samples attributable to ration (Table 3). Tenderness scores for the light meat samples show that chickens fed the RSMHM diet were less tender ($P < 0.05$) than comparable samples from chickens fed either the SBM or RSM rations. Feeding the SBMF ration to broilers resulted in light meat of similar tenderness to that of comparable samples from broilers fed the other rations (Table 3). Warner Bratzler shear force values for light meat samples were slightly higher (less tender) for cores obtained from chickens representing the RSMHM ration, however no significant differences attributable to ration were found (Table 2).

The data (Table 3) show that panelists scored the odor of dark meat from chickens fed the RSMHM ration lower ($P < 0.05$) than that of comparable samples from chickens representing the other three ration treatments. The flavor and overall acceptability of dark meat samples taken from chickens fed the RSMHM ration were rated significantly lower than the flavor and overall acceptability of comparable samples from broilers raised on the SBM, SBMF and RSM rations. Inclusion of 15% rapeseed meal in the rations of broilers (RSM ration) resulted in flavor and overall acceptability scores for dark meat which were significantly lower than the scores assigned to comparable samples from chickens fed the SBM (control) ration. Table 3 also in-

dicates that the flavor and overall acceptability of samples of dark meat taken from chickens raised on the SBMF ration were similar to that of comparable samples from the SBM and RSM diets. Panelists repeatedly commented that the odor and flavor of dark chicken meat from the RSMHM ration treatment was "fishy", "unpleasant", "rancid" or "stale". According to some of the judges, dark meat samples from chickens fed the RSM ration had a "stale" or "more oily" flavor than samples from chickens fed the SBM (control) ration. In addition, dark meat samples from all ration treatments received lower scores for odor, flavor and overall acceptability than comparable light meat samples (Table 3).

There were no significant differences in juiciness of dark meat samples attributable to ration treatment. However, juiciness scores assigned to dark meat samples were higher than those scores given to light meat samples (Table 3). Since the muscle tissue of the thigh has a higher lipid and collagen content than muscle tissues of the breast of chickens, these data are as would be expected. The tenderness score for dark meat samples from chickens raised on the RSMHM ration was significantly lower than that of comparable samples from chickens fed either the SBM or SBMF rations. Feeding broilers rapeseed meal at the 15% level (RSM ration) resulted in dark meat samples with a tenderness score similar to that of comparable samples from chi kens fed the other three rations. Warner-Bratzler shear

data for dark meat samples did not support taste panel scores (Table 2).

Trends similar to those obtained for the odor and flavor of light meat and dark meat samples were observed for the odor and flavor of broths prepared from chickens raised on the four rations. The odor score for broths made from chickens fed the RSMHM ration was lower ($P < 0.05$) than scores for broths prepared from comparable chickens of the other ration treatments (Table 3). Judges also scored the flavor of the chicken broth samples representing the RSMHM ration lower ($P < 0.05$) than that of broths made from comparable chickens fed the SBM, SBMF and RSM rations. The data indicate that broths prepared from chickens fed either the SBMF or RSM rations had significantly less desirable flavor than broth samples made from broilers fed the SBM ration (Table 3).

In general, the results of the present study show that 15% rapeseed meal plus 5% herring meal with added DL methionine (0.1%) and choline chloride (0.05%), i.e. the RSMHM ration, when fed to broilers produced off-odors and off-flavors in chicken. Descriptions given by the judges for the light and dark meat samples from the chickens fed the RSMHM ration were "fishy", "unpleasant", "rancid" or "stale". Opstvedt (1971) suggests that the off-flavor in poultry meat associated with fish meal feeding more closely resembles the taste and smell of rancid fish than of fresh fish. In his experiments, the terms "rancid" and "fish taint" were used synonymously.

Feeding high levels of various types of fish meal (Rojas et al., 1969; Atkinson et al., 1972 a, 1972 b) to broilers caused off-flavor and off-odor in the chicken meat. erally, researchers (Hardin et al., 1964; Fry et al., 1965; Rojas et al., 1969; Atkinson et al., 1972 a, 1972 b) have established that the level of fish meal required to produce tainted meat is much greater than the 5% herring meal (containing approximately 7% residual oil) present in the RSMHM ration of this study. Dean et al. (1969), investigating the flavor associated with fish meals containing 9.2% residual fat, reported that flavor differences between broilers fed a control ration containing 3% white fish meal and broilers fed a ration containing 9% white fish meal were detected with a frequency that was highly significant in skin and breast meat. However, in thigh meat flavor differences were detected only after a ration containing 14% fish meal was fed to broiler chickens (Dean et al., 1969). Rojas et al. (1969) fed levels of up to 8% Peruvian anchovy meal (4-8% fat) in rations without producing fishy flavor in broiler meat. Neutral flavor in broiler meat was reported by Atkinson et al. 1972 b) who also fed levels of 8% stabilized fish meal.

According to Opstvedt (1971), the flavor deterioration compounds in fish meals are believed to reside in the lipid soluble fraction. Fry et al. (1965) concluded that levels of 1.25% fish oil in the rations were critical in producing off-flavors and off-odors in the broiler meat of chickens

fed a ration containing fish oil. A significant negative correlation was observed between long chain polyunsaturated fatty acids and the flavor quality of chicken meat (Opstvedt, 1971). Fish meals are known to contain residual long chain polyenoic fatty acids (Opstvedt, 1971, 1974; Atkinson et al., 1972 a, 1972 b; Wessels et al., 1973). When fish meal is fed to chickens the long chain polyenoic fatty acids in the residual oil of the meal will be reflected in the muscle tissue of the chicken. In the present study however, 5% herring meal (containing about 7% fat) in the RSMHM ration probably did not provide the level of fish oil and, thus, the level of polyunsaturated fatty acids necessary to produce off-odors and off-flavors in the chicken meat. In addition, the 15% Span rapeseed meal (with 1 to 2% residual oil) included in the RSMHM diet would contribute only a small amount of long chain polyunsaturated fatty acids (linolenic, eicosenoic and erucic) which might influence chicken flavor. Thus, factors other than the level of fish meal and residual fish oil (or fatty acid composition of the residual fish oil) and/or the residual oils in the rapeseed meal must be involved in the production of fishy odors and flavors determined in chicken carcasses when the RSMHM ration was fed to broilers.

In the present study, the incorporation of additional methyl groups, as DL methionine (0.1 %) and choline chloride (0.05 %), to the rapeseed meal ration containing 5% herring meal (RSMHM ration) may have contributed to the off-odors

and off-flavors determined in broiler meat due to the production of trimethylamine. Trimethylamine (TMA), a protein degradation product, has been isolated in the flesh of fish and is one of the components responsible for fish odor (Halloran, 1972). Both Atkinson et al. (1972 b) and Wessels et al. (1973) noted that the addition of amines to rations containing fish meals intensified the "fishy" taint in the broiler meat. In studies of broiler flavor, Halloran (1972) investigated the effect of the addition of TMA to rations containing 0 to 1.50% fish oil. TMA had a consistent effect on the production of fishy flavors, regardless of level of oil. Off-flavors most frequently mentioned (in decreasing order) were bitter, fishy, strong, fish oil and oily. In another experiment, Halloran (1972) added 0.101% TMA to a ration containing 3.4% fish meal. No fishy flavors in meat were reported when this ration was fed to chickens; however off-flavors described as bitter, oily or strong were produced in 15.6% of the broilers on the TMA-fish meal diet ($P < 0.05$).

In contrast, Hanson et al. (1959) reported no significant difference in the flavor of modern-type broilers fed a diet containing 4.0% fish meal with 0.1% DL methionine and 0.025% choline chloride and old-type broilers fed a ration containing 10% fish meal. With the exception of the inclusion of 15% rapeseed meal, the modern type ration used by Hanson et al. (1959) was very similar to the RSMHM ration in the present experiment. Therefore, perhaps some interaction between the rapeseed meal, and/or the herring meal,

and/or the added methyl groups may account for the off-odors and off-flavors determined in the chicken samples obtained from broilers fed the RSMHM ration.

The concentration of free TMA in rapeseed meal is very low (Hobson-Frohock et al., 1973). Hobson-Frohock et al. (1975) postulate that active rapeseed meal may contain either an inhibitor to trimethylamine oxidase or an excess of a precursor to TMA production. Thus, it is possible that the presence of an enzyme inhibitor or a TMA precursor (in the rapeseed meal and/or the herring meal) along with the dietary source of TMA (DL methionine and choline chloride) in the RSMHM ration may be responsible for the decreased odor and flavor of chickens raised on the RSMHM diet.

The inclusion of Span rapeseed meal (15%) in the ration of broiler chickens (RSM ration) resulted in dark meat and broth samples with significantly lower flavor scores than comparable samples from control chickens fed the SBM ration (Table 3). Yule and McBride (1976) observed that 5% rapeseed meal in the ration resulted in no detectable effects on appearance, color, flavor, texture and acceptability of broiler meat. However, they suggested that levels of rapeseed meal above 5% may cause off-flavors in broiler meat. No published reports have examined whether feeding rapeseed meal at levels (15%) present in commercial poultry feeds produced in Canada causes off-flavors and off-odors in poultry meat.

Reports of off-flavor and off-odors in meat from sheep grazing on rape (B. napus) have been documented from Austra-

lia (Spurway, 1972; Park et al., 1972; Wheeler et al., 1974). Also, rapeseed meals have been implicated in the production of off-flavors and off-odors in eggs laid by certain strains of hens fed laying rations containing rapeseed meal (Hawrysh et al., 1975; Blair et al., 1975; Overfield and Elson, 1975; Bolton et al., 1976).

The SBMF ration was devised to contain a level of fat and fiber similar to that of the 15% Span rapeseed meal (RSM) ration. The higher fat and fiber content of the SBMF did not seem to affect the eating quality of broiler chickens as compared to chickens raised on the SBM (control) ration. For most quality characteristics, chickens representing the SBMF ration were similar to the chickens fed the RSM ration.

Subjective Evaluation by a Consumer Panel

A questionnaire (Appendix, Figure 5 , page 113), included in the consumer packet, provided general information about the participants in the consumer study. The findings of the questionnaire are summarized in Figures 7, 8, 9, 10, 11, 12, 13, and 14. Of a sample of 144 consumers, 50% of the homemakers were gainfully employed while the other half were not (Figure 7 a). Gainfully employed consumer homemakers were subsequently categorized according to type of employment (Figure 7 b). Thirty-five percent of the gainfully employed respondents were employed as profession-

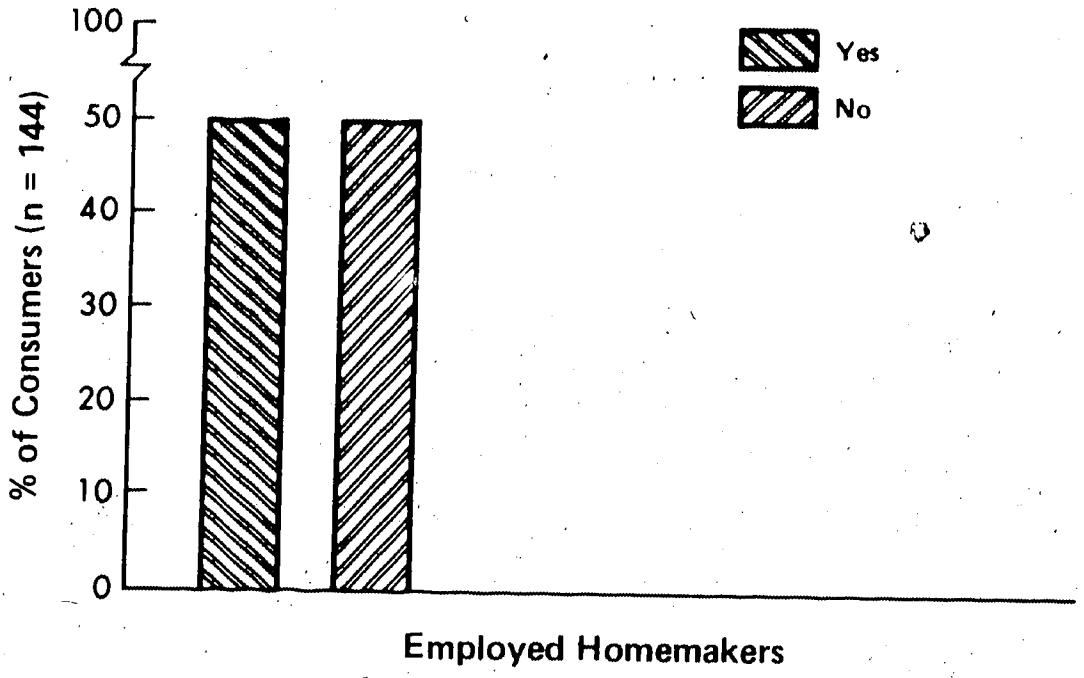


Figure 7 a. Percentage of consumer homemakers gainfully employed.

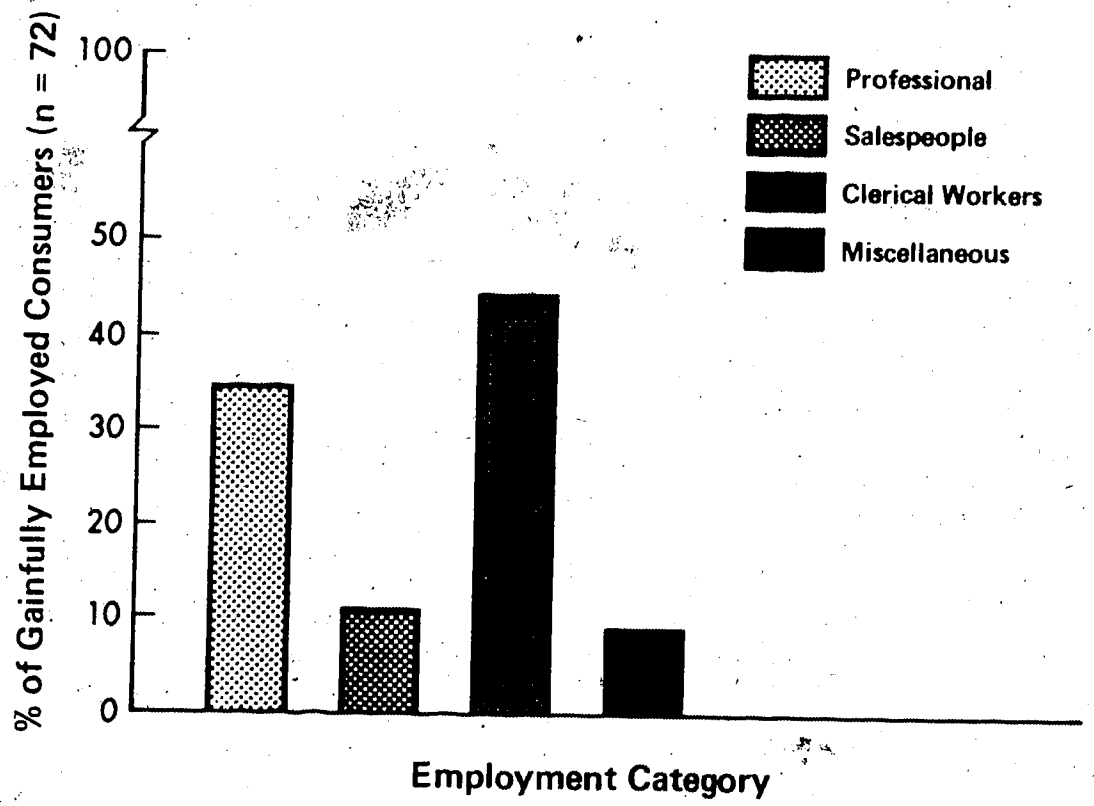


Figure 7 b. Percentage of gainfully employed consumer homemakers in each employment category.

als (teachers, nurses, home economists, social workers, etc.), 11% were salespeople, 45% were clerical workers (secretaries, bank tellers, typists, bookkeepers, etc.) and 9% were employed in miscellaneous jobs.

In this study an attempt was made to insure that all age groups of homemakers were represented. Figure 8 illustrates the age distribution of the consumers that participated in this study. Twelve percent of the homemakers were 24 years of age or less; 35% were in the 25 to 34 year age group; 18% were 35 - 44 years old; 19% were in the 45 to 54 year age category; while the remaining 16% were 55 years of age and older. Data relating to family size of consumer households are illustrated in Figure 9. It is interesting to note that the most common family size of participants in this study was either 2 or 4, which accounted for 25 and 26% of the study population, respectively.

Findings of the questionnaire also revealed that for 32% of the respondents in this study farming was the occupation of the main wage earner (Figure 10). Occupations listed by the remainder of the main wage earners were professionals, such as doctors, lawyers, teachers, accountants, etc. (19%), skilled laborers (17%), clerical workers (13%), business executives (8%), retired (6%), unskilled laborers (3%) and salespeople (2%).

Figure 11 illustrates the percentage of main wage earners who represented each of five work situations. A large proportion (39%) of the main wage earners owned and managed their own business or farm, while 32% worked for

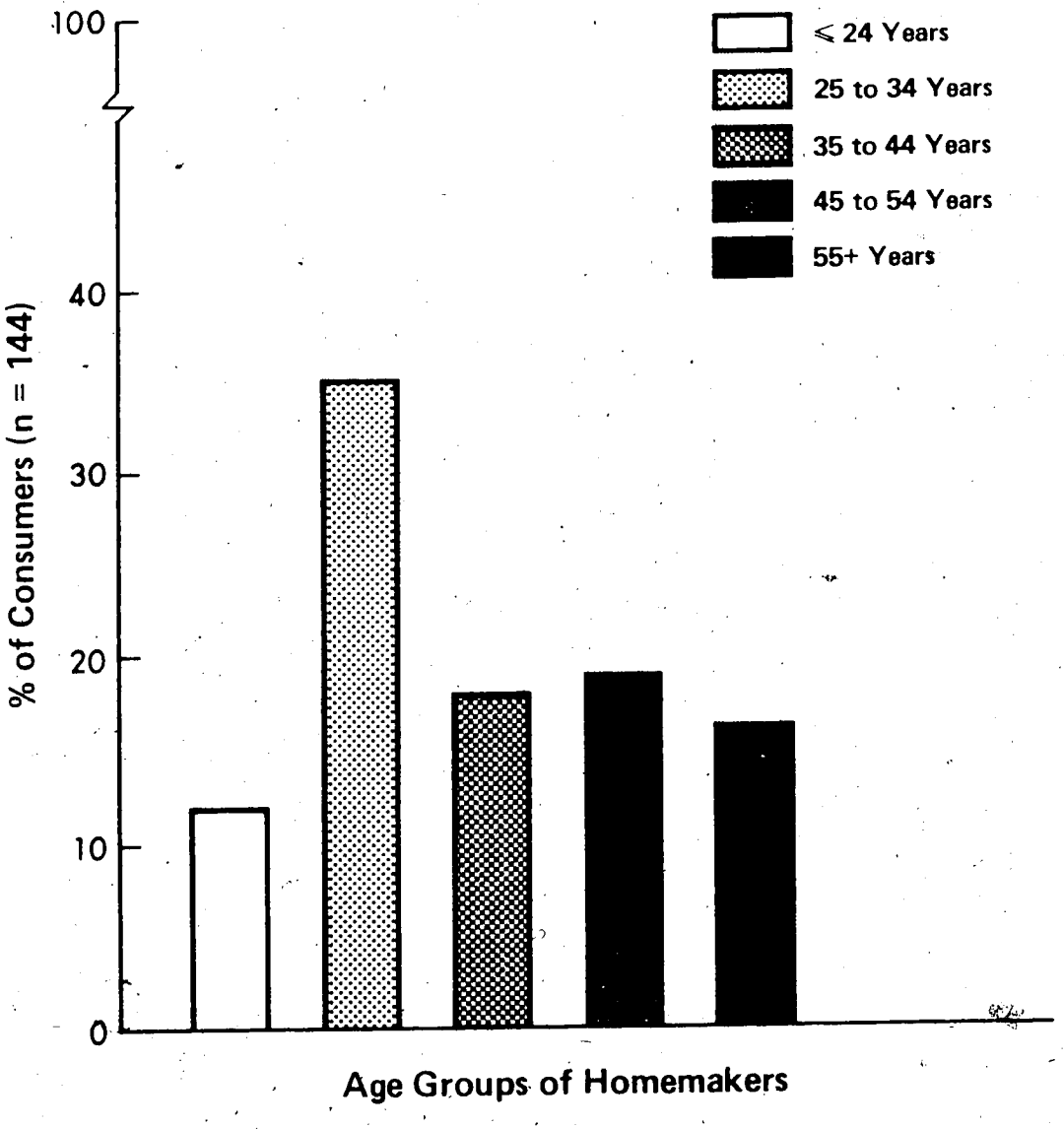


Figure 8. Age distribution of participating consumer homemakers.

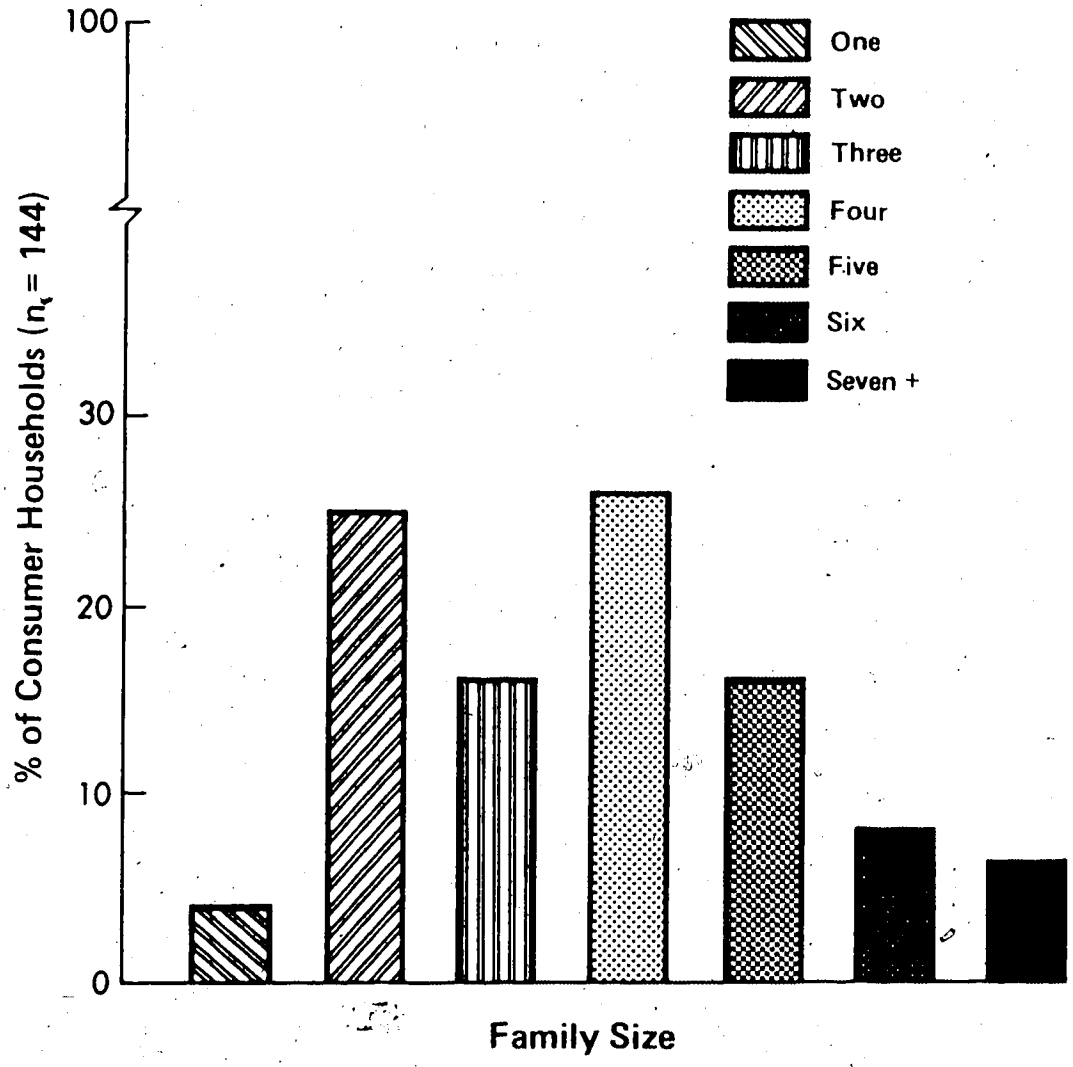


Figure 9. Family size of participating consumer households.

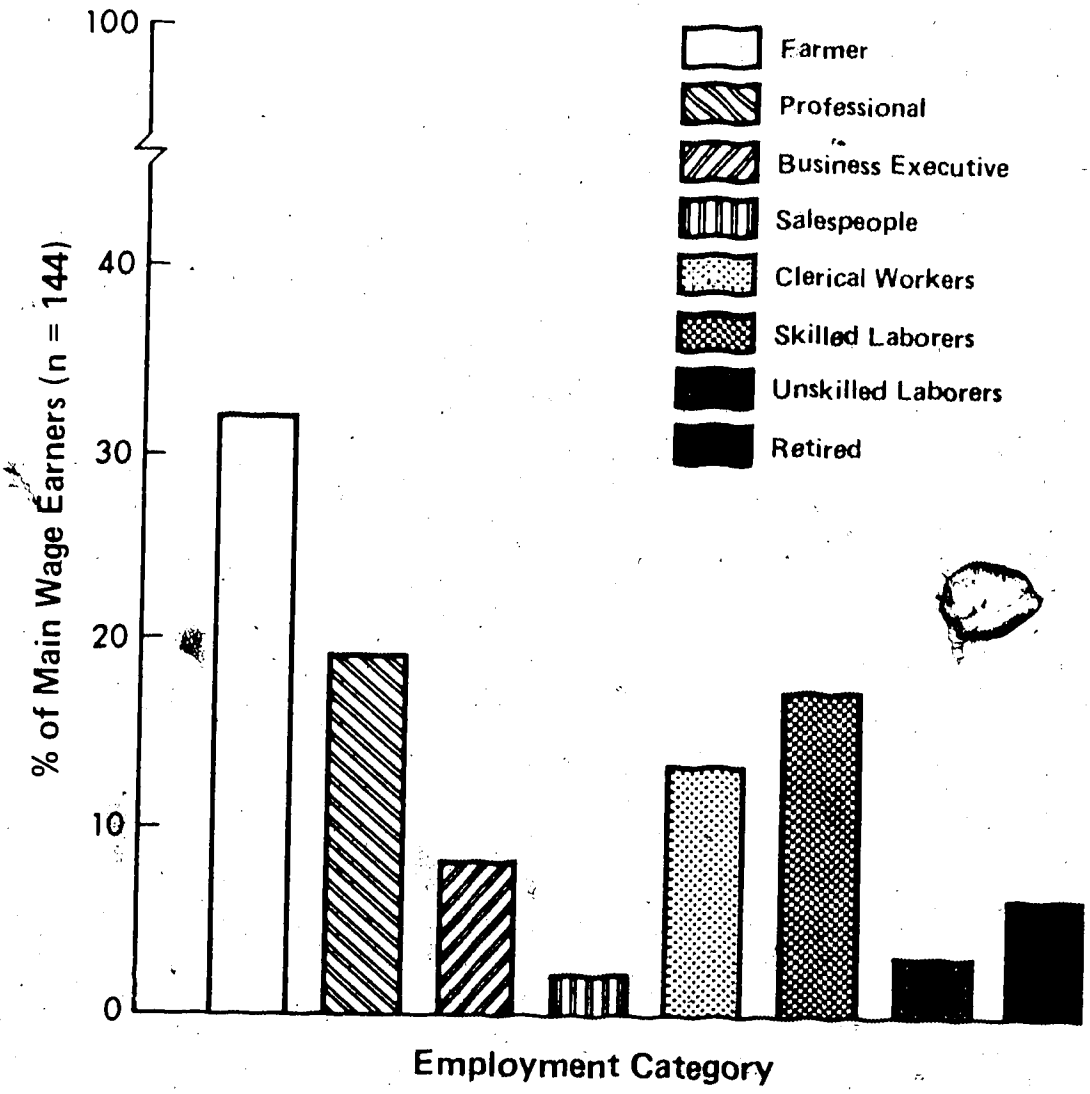


Figure 10. Percentage of main wage earners occupied in various employment categories.

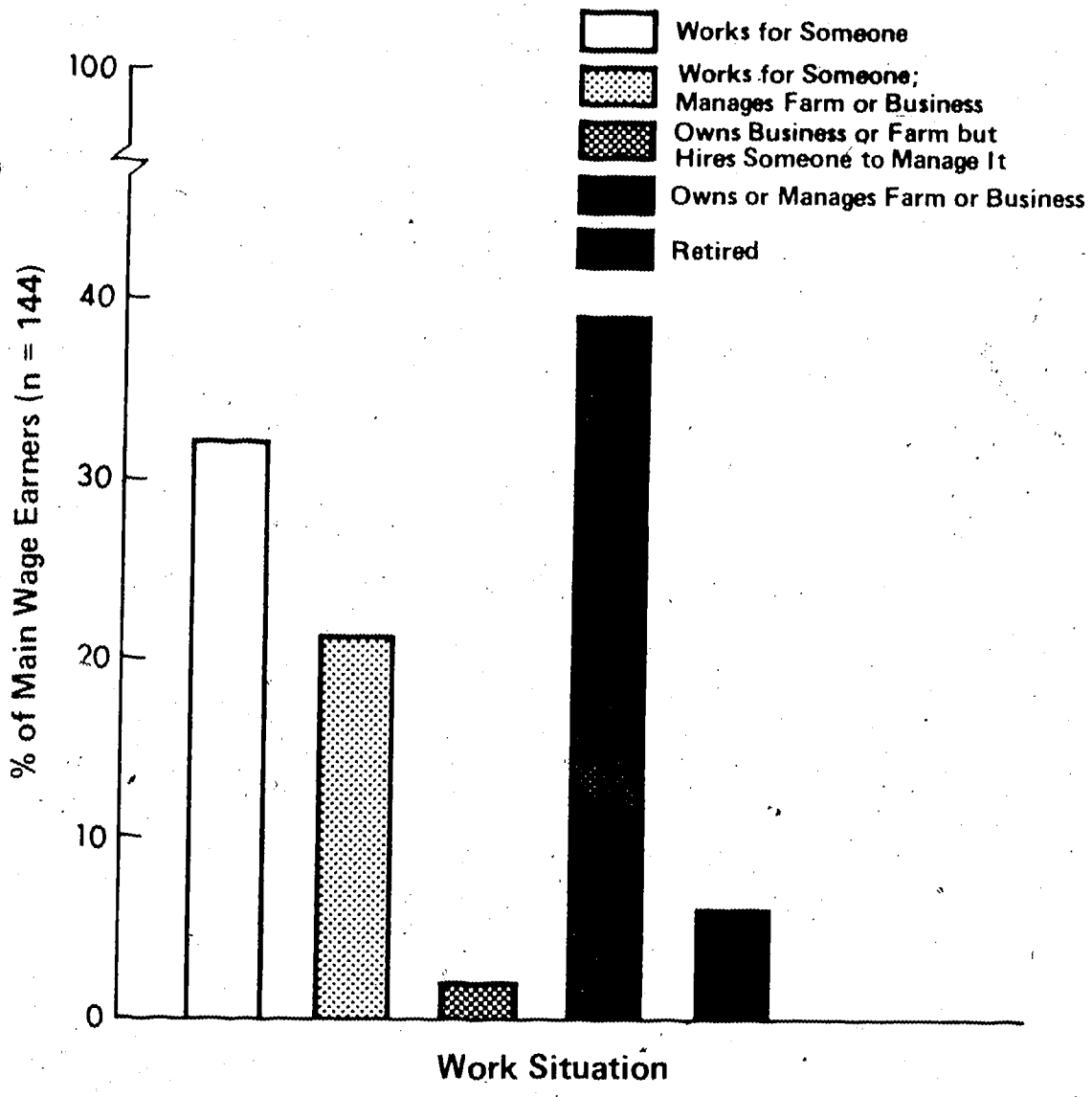


Figure 11. Work situation of the main wage earner from participating consumer households.

someone else. Twenty-one percent of the main wage earners worked for someone else, but in a managerial capacity. A small proportion of the main wage earners were retired (6%). Two percent of the main wage earners owned a business or farm but employed someone else to manage it (Figure 11).

Since willingness to participate in this study was one of the criteria in the selection of the consumer panel, none of the participants disliked chicken. The majority of consumers (57%) liked chicken very much, 38% liked chicken and 5% neither liked nor disliked it (Figure 12). Replies to the question regarding the frequency of serving chicken, indicated that 39% of the participants served chicken 2 to 3 times per month, 28% served chicken once a month, 26% served it once a week, 6% of the respondents served chicken less than once a month, and 2% served chicken two or more times per week (Figure 13).

Although a high percentage of farm families (32%) participated in this study, it was interesting to find that most of the consumers purchased chicken from either a local store (49%) or a private seller (37%) (Figure 14). Only 11% of the participants in this study raised and killed their own chickens. The remaining consumers (3%) obtained their chickens from other sources.

Results of the consumer panel evaluations of cooked chicken meat (Table 4) indicate that feeding the RSMHM ration to chickens resulted in lower ($P < 0.05$) scores for odor, flavor and overall acceptability than the scores assign-

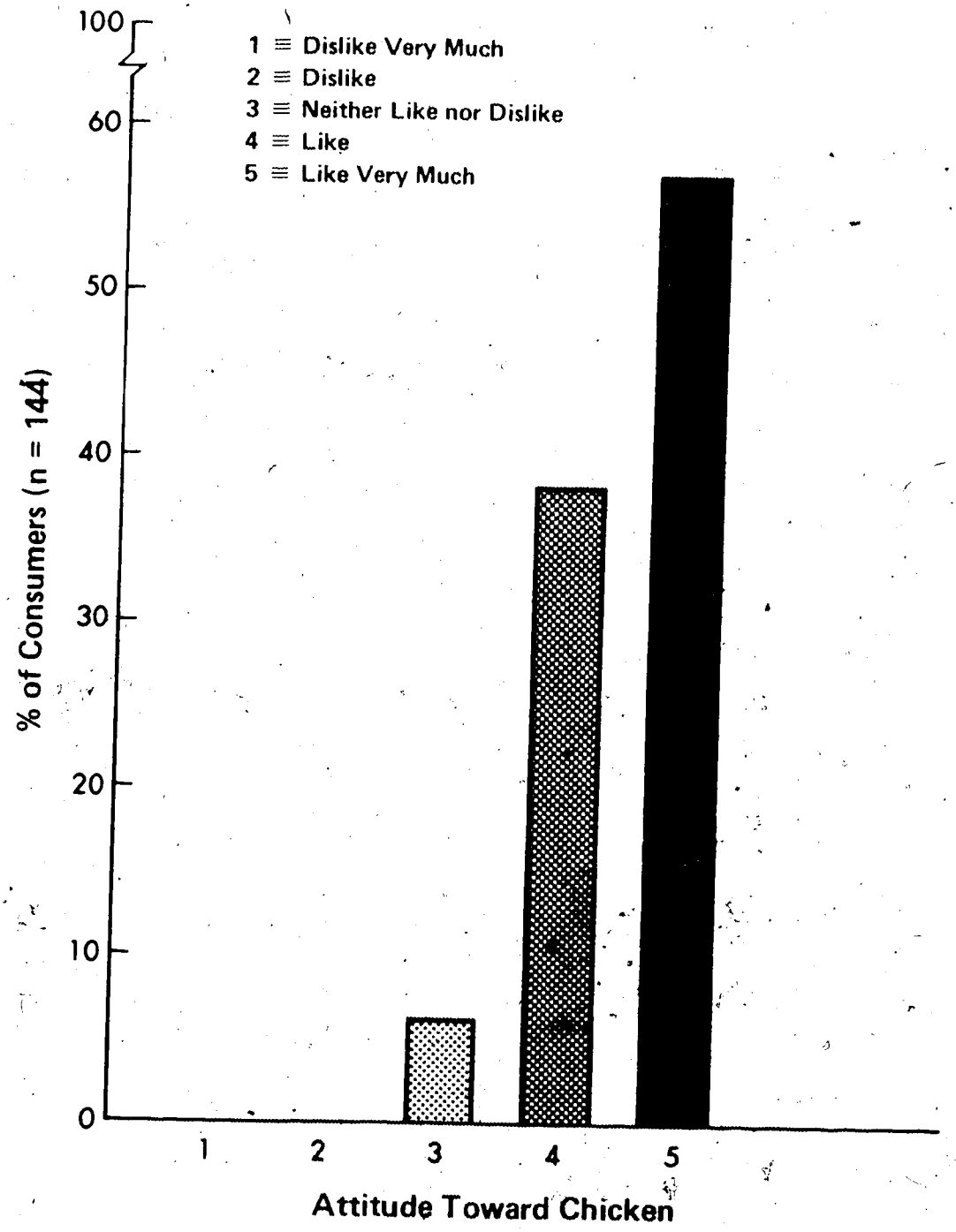


Figure 12. Attitude toward chicken of participating consumers.

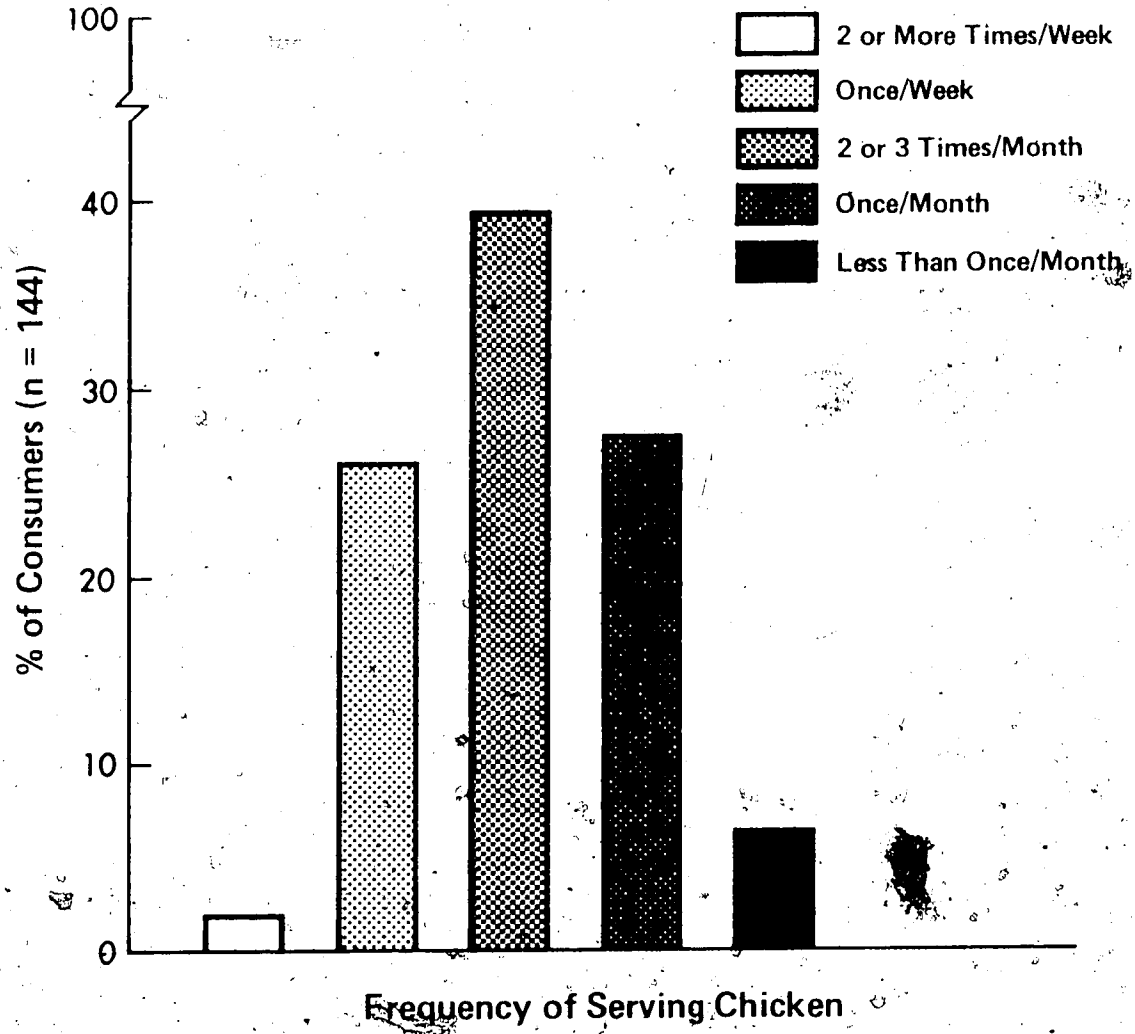


Figure 13. Frequency of serving chicken in participating consumer households.

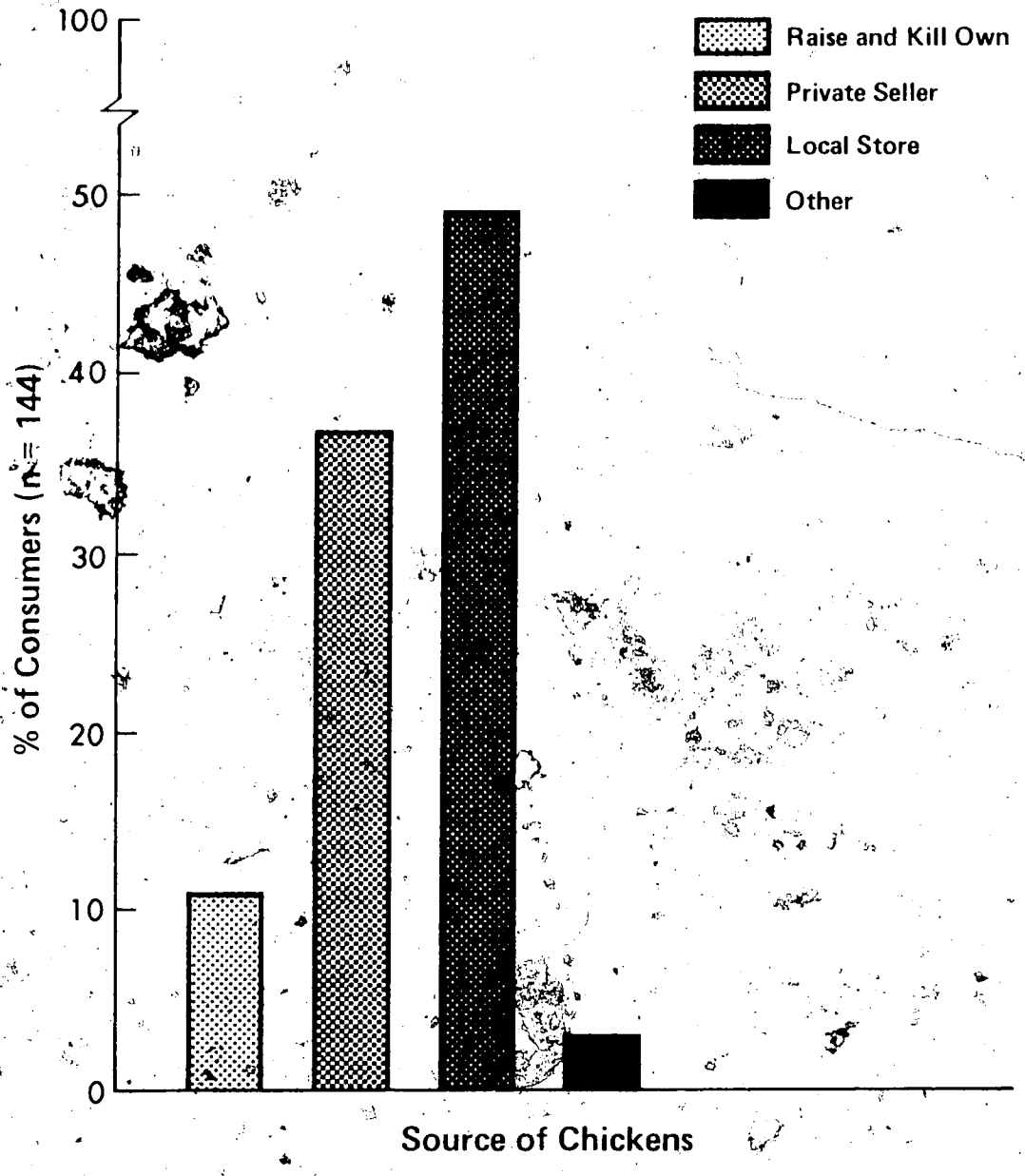


Figure 14. Source of chickens for participating consumers.

Table 4. Means and SE[1] for subjective evaluations by a consumer panel for chicken meat from chickens fed the three rations.

Measurements	Ration[2] SBM	RSM	RSMHM	SE
Odor[3]	3.8[a]	3.6[a]	3.3[b]	.09*
Flavor[3]	4.0[a]	3.9[a]	3.4[b]	.08*
Overall acceptability[3]	3.9[a]	3.7[a]	3.3[b]	.08*
Preference[4]	1.8[b]	1.9[b]	2.3[a]	.07*

[1]Standard error of the means.

[2]See footnotes 1, 3 and 4, Table 1, page 22.

[3]Five point scale with 5 being the highest score and 1 being the lowest. Values are the means of 144 determinations.

[4]Three point scale with 1 being "most preferred" and 3 being "least preferred". Values are the means of 142 determinations.

[ab]Means within the same row sharing a common superscript letter are not significantly different at $P \leq 0.05$.

*Significant at $P < 0.05$.

ed to comparable samples from chickens fed the SBM and RSM rations. For each of the three palatability characteristics evaluated, the consumer panelists assigned slightly lower scores to the cooked samples obtained from chickens fed the RSM ration than to comparable samples from chickens fed the SBM (control) ration, but the differences were not significant. Consumer panel judgements for odor, flavor and overall acceptability of chickens representing the SBM, RSM and RSMHM ration treatments were slightly higher but the trends were similar to those of the trained panel (Table 4). Carlson et al. (1957) obtained similar results from a consumer panel and from a trained panel for an evaluation of the amount of menhaden fish oil or beef tallow that could be added to the diet without impairing the flavor of broilers.

Consumer panelists also rated the cooked chicken samples for preference (Table 4). Mean scores given to each of the rations for preference rating indicate that the chickens raised on the RSMHM ration were rated significantly lower (i.e. had a higher score denoting lower preference) than the chickens fed either the SBM or RSM rations, which were rated similarly. Table 5 shows that 40.6% of the respondents rated chickens fed the SBM (control) ration as "most preferred"; while only 21.7% of the participants rated chickens from the RSMHM ration group as "most preferred". In contrast, chickens from the RSMHM ration

Table 5. Percentage of consumers[1] ranking chickens fed the three rations in each preference category.

Ration[2]	Preference Rating[3] 1	2	3
SBM	40.6%	37.3%	21.8%
RSM	37.8%	33.1%	29.6%
RSMIM	21.7%	29.6%	48.6%

[1]Percentage values are calculated as the number out of 142 participants who assigned each ration to a specific preference category.

[2]See footnotes 1, 3 and 4, Table 1, page 22.

[3]Preference rating: 1, "most preferred" and 3, "least preferred".

treatment were ranked as "least preferred" by 48.6% of the consumers; while only 21.8% of the consumers rated the chickens fed the SBM ration as "least preferred". Preference ratings for chickens fed the RSM ration were between those of the other two rations (Table 5).

Storage

Objective Measurements

Table 6 presents data for the objective measurements of fresh chickens and frozen chickens stored for either 18 days or 6 months. Percentage thaw loss for chickens frozen and stored 18 days was lower ($P < 0.05$) than the thaw loss for comparable chickens frozen and stored 6 months. There were no significant differences in initial raw weight, cooked weight, cooking loss (total, volatile and drip), percentage total moisture or percentage ether extract attributable to storage (Table 6). In a study of freezing methods for chicken, Streeter and Spencer (1973) found that non-frozen chicken halves had lower ($P < 0.05$) mean cooking losses than comparable chicken halves subjected to freezing. Wyche et al. (1972) reported no difference in moisture content between cooked samples analyzed initially and cooked chicken breasts or thigh drum samples stored frozen for three months. The precooked, frozen breast and thigh drum parts stored for three months had a higher percentage fat content than comparable fresh cooked chicken parts analyzed immediately after cooking (Wyche et al., 1972).

Table 6. Means and SE[1] for objective measurements for fresh chickens and frozen chickens stored 18 days and 6 months

Measurements	Fresh	Frozen Storage Short (18 days)	Frozen Storage Long (6 months)	SE
Thaw loss (%)[2]	--	2.8	3.5	.09*
Initial raw weight (g)[2]	1151.2	1122.7	1113.9	12.47
Cooked weight (g)[2]	849.0	832.7	837.2	19.18
Cooking losses (%)[2]				
Total	26.2	25.8	24.8	.72
Volatile	20.5	20.4	19.3	.72
Drip	5.7	5.4	5.5	.16
pH[3]				
Broth	6.7[a]	6.6[b]	6.7[a]	.01**
Cooked meat	6.2	6.2	6.2	.01
Total moisture (%)[4]	64.2	64.5	64.6	.38
Ether extract (%)[4]	4.9	4.6	5.2	.19
TBA number[4]	8.7[a]	7.2[a]	4.5[b]	.66**
Monocarbonyls (µg/g fat)[5]	.12	.12	.14	.01
Shear force (kg/cm core)[6]				
Light meat	2.3[a]	2.5[a]	1.9[b]	.09***
Dark meat	1.2	1.1	1.0	.05
Water holding capacity[7]	.67[a]	.65[ab]	.61[b]	.01*

[1]Standard error of the means.

[2]Values are the means of 48 determinations. (Initial raw weight - wing tips & neck removed.)

[3]Values are the means of 96 determinations, two per chicken.

[4]Values are the means of 48 determinations, two on each of 24 chickens.

[5]Values are the means of 24 determinations, two on each of 12 chickens.

[6]Values are the means of 192 determinations, four per chicken.

[7]1.0 - (expressible liquid index); the larger the value the greater the amount of liquid expressed. Values are the means of 144 determinations, three per chicken.

[ab]Means within the same row sharing a common superscript letter are not significantly different at P<0.05).

*Significant at P<0.05.

**Significant at P<0.01.

***Significant at P<0.001.

Data for pH of broth samples from frozen chickens stored 18 days were lower ($P < 0.05$) than comparable broth samples from either fresh chickens or frozen chickens stored for 6 months (Table 6). Since broth pH determinations were an average of 48 duplicate readings, a difference of one-tenth pH unit was significant. Pippen et al. (1965) reported that differences in pH as great as 0.4 pH unit had little, if any, influence on broth flavor. Therefore, the difference in pH determined in the present study probably has little influence on broth flavor. Storage treatment had no significant effect on the pH readings of the cooked meat samples (Table 6).

The TBA number (Table 6) for frozen chicken stored for 6 months was lower ($P < 0.05$) than the numbers for comparable samples of either fresh chickens or frozen chickens stored 18 days. The TBA test has been used by several workers (Martinson and Carlin, 1968; Sims and Carlin, 1968; Harris and Lindsay, 1972; Wyche et al., 1972; and Dawson and Schierholz, 1976) to determine lipid oxidation during the storage of poultry products. Some of these researchers found that TBA values remained the same (Martinson and Carlin, 1968; Sims and Carlin, 1968) as storage time at -18° increased up to 12 months. Wyche et al. (1972) observed higher TBA numbers in cooked breast and thigh drum samples after 3 months frozen storage than those determined in fresh cooked breast and thigh drum samples from broilers. Arafa and Chen (1976) noted that the TBA number for pre-cooked chickens reached a maximum value at the fourth month of storage and then decreased before leveling off at 6 months.

The TBA test measures the concentration of malonaldehyde, a reaction product of lipid oxidation. In the present study, the loss of malonaldehyde and subsequent decrease in the TBA value determined for broiler meat from frozen chickens stored 6 months may be due to the formation of carbonyl addition products (Chang et al., 1961) or to a reaction of myosin and malonaldehyde (Buttkus, 1967) during frozen storage. Dawson and Schierholz (1976) suggested that the products responsible for the TBA reaction are produced and recombined in food systems in an erratic fashion. Therefore, TBA results are not always as expected.

In this experiment, total monocarbonyls in the fat from cooked chicken skin and from the pan drippings were also analyzed as a measure of lipid oxidation in the chickens. However, there were no significant differences in monocarbonyls attributable to storage treatment (Table 6). Dimick and MacNeil (1970), studying storage time-temperature effects on carbonyl composition of cooked turkey and chicken skin fractions, reported that as the period at -17.8° increased from 0 to 23 weeks, monocarbonyl content increased fairly consistently.

Warner Bratzler shear force values for light and dark chicken meat samples are also given in Table 6. Light meat cores taken from chicken frozen and stored for 6 months were more tender ($P < 0.05$) than comparable cores from either fresh chickens or frozen chickens stored 18 days. There were no significant differences in shear force values for

dark meat samples attributable to storage. However, the force required to shear dark meat samples was consistently lower than the force needed to shear light meat samples.

Few studies have determined the relationship between tenderness and length of frozen storage in poultry using Warner Bratzler shear measurements. Streeter and Spencer (1973) reported similar Warner Bratzler shear values for non-frozen chicken halves and for chicken halves frozen by the air blast method and stored one week. Goertz et al. (1960) found that Warner Bratzler shear values for 1.3 cm cores of dark turkey meat frozen and stored at -17.8° for 3 months were lower ($P < 0.05$) than those for comparable cores from turkeys frozen and stored one month.

Water holding capacity data (Table 6) were lowest for chickens frozen and stored for six months; highest for fresh chickens ($P < 0.05$). Chickens frozen and stored a short period of time had an intermediate value for WHC, which was similar to the WHC values of fresh chickens and frozen chickens stored 6 months. Goertz et al. (1960) reported similar water holding capacity values for both fresh-unfrozen turkeys and frozen turkeys stored either one month or 3 months.

Subjective Evaluation by a Trained Panel

Table 7 summarizes data for subjective evaluations of light meat, dark meat and broth samples obtained from fresh

Table 7. Means and SE[1] for subjective evaluations by a trained panel for light meat, dark meat and broth samples from fresh chickens and frozen chickens stored 18 days and 6 months.

Measurements	Fresh	Frozen Storage Short (18 days)	Long (6 months)	SE
Light Meat[2]				
Odor	4.4[a]	4.2[b]	4.1[b]	.04*
Flavor	4.4	4.2	4.0	.08
Juiciness	4.0[ab]	3.8[b]	4.2[a]	.07*
Tenderness	5.1	4.9	5.0	.06
Overall acceptability	4.4	4.2	4.0	.12
Dark Meat[2]				
Odor	3.8[ab]	3.6[b]	3.9[a]	.05*
Flavor	3.8	3.7	3.8	.06
Juiciness	4.6	4.5	4.6	.07
Tenderness	4.9	5.1	5.1	.07
Overall acceptability	3.7	3.7	3.8	.08
Broth[3]				
Odor	4.2[a]	4.0[ab]	3.9[b]	.05*
Flavor	3.9	3.8	3.6	.06

[1]Standard error of the means.

[2]Seven point scale with 7 being the highest score and 1 being the lowest score. Values are the means of 48 judgments by each of 6 panelists.

[3]Five point scale with 5 being "no difference" and 1 being "extreme difference". Values are the means of 48 judgments by each of 6 panelists.

[ab]Means within the same row sharing a common superscript letter are not significantly different at $P \leq 0.05$.

*Significant at $P < 0.05$.

chickens and frozen chickens stored for either 18 days or 6 months. Odor scores for light meat samples from chickens frozen and stored for either 18 days or 6 months were significantly lower than the odor score for comparable samples taken from fresh chickens. Data for flavor and overall acceptability of light meat indicate that these quality scores decreased as length of frozen storage increased; however, the results were not significant. Light meat samples obtained from chickens frozen for a short time received a lower ($P < 0.05$) juiciness score than comparable samples from frozen chicken stored 6 months. The juiciness score assigned to light meat from fresh chickens was similar to that given to light meat samples taken from chickens from both frozen storage treatments. Storage treatment did not affect the tenderness scores of light meat samples (Table 7). Water holding capacity and Warner Bratzler shear data do not support subjective evaluations of juiciness and tenderness, respectively (Table 6). Other workers, Goertz et al. (1960) have found that press fluid values and juiciness scores, as well as shear force values and tenderness scores do not always agree.

The odor of dark meat samples from chickens frozen and stored for 18 days was significantly lower than the odor of comparable samples from chickens assigned to long frozen storage (Table 7). The odor score for dark meat samples from fresh chickens was similar to the odor scores for dark meat from both frozen storage treatments. There were

no significant differences in the flavor, juiciness, tenderness and overall acceptability of dark meat samples attributable to storage treatment. Objective tenderness determinations (Warner Bratzler shear values, Table 6) also show no effect due to storage.

Taste panel data for broth indicate that the broth prepared from chickens frozen for 6 months had a less desirable odor than comparable samples made from fresh chickens (Table 7). Broth made from frozen chickens stored 18 days received an odor score similar to that of comparable broths from the other two storage treatments. Although data for the flavor of broth samples show trends similar to those determined for odor, these differences were not statistically significant.

Generally, the eating quality of the broilers was not influenced by the storage treatments investigated in the present study, with the exception of odor scores for light meat and broth samples previously noted. There have been few reports of the effects of length of frozen storage on eating quality of broiler chickens. An early study by Stewart et al. (1945) noted that in shorter frozen storage periods (9 and 23 days) the differences in palatability scores (including aroma, flavor, juiciness and tenderness) between fresh controls and frozen broilers were not significant. However, with longer frozen storage (up to 79 days) palatability scores of frozen broilers decreased, the differences between fresh controls and frozen broilers

becoming highly significant. Spencer et al. (1961) found no significant differences in the flavor of chicken meat attributable to frozen storage at -17.8° for 2 to 12 weeks. However, they observed lower ($P < 0.01$) flavor scores for extracted broth samples obtained from chickens that were held frozen for short periods of time (2 to 8 weeks and 12 weeks). On the basis of their experiment, Spencer et al. (1961) suggested that the loss in flavor found in frozen broilers was not enough to be detected by the consumer during normal cooking.

Wills et al. (1948), investigating longer frozen storage periods, reported that poultry was still palatable after 9 months of frozen storage at -23.2°. However, Koonz et al. (1947) found that cut-up pullets wrapped in moisture-proof cellophane and stored at -17.8° for 9 months showed appreciable deterioration in flavor and appearance. Later research by Klose et al. (1959) on the effect of frozen storage on ready-to-cook cut-up chicken, suggested that 3, 6, 9 and 18 months were optimum storage periods for chicken at temperatures of -7°, -12°, -18° and -23° respectively. This study (Klose et al., 1959) emphasized the close relationship that exists between processing, packaging and temperature.

Thus, the data for the influence of storage on the eating quality of broilers in the present study are as would be expected since the chickens were well-packaged and stored at a constant, very low temperature (-29°). Further-

more, the longest storage period in this experiment, 6 months, is shorter than the one year period of frozen storage generally suggested as optimum for insuring broiler quality.

Ration by Storage

Objective Measurements

Data for all the objective measurements for the interaction of ration and storage are given in the Appendix, Table 1 page 106.

Subjective Evaluation by a Trained Panel

The complete data for subjective evaluations by a trained panel of ration by storage interactions are presented in the Appendix, Table 2 , page 107. Mean scores for odor and flavor of light meat, dark meat and broth are summarized in Table 8 . Light meat samples showed significant differences ($P < 0.05$) for odor attributable to ration by storage interaction. The data for ration within each storage period indicate that the odor scores for chickens fed the RSMHM ration were significantly different from the other three rations for each of the storage times. However, odor scores for light meat from chickens fed the SBM, SBMF and RSM rations varied according to the specific storage period. Light meat samples from chickens fed the SBM (control) ration and cooked fresh had the highest score and

Table 8. Means and SE[1] for subjective evaluations by a trained panel for the odor and flavor of meat, dark meat and broth samples for ration by storage treatment combinations.

Measurements	Ration by Storage Treatment Combinations[2]												SE
	Fresh				Short Frozen (18 days)				Long Frozen (6 months)				
	SBM	SBMF	RSM	RSMHM	SBM	SBMF	RSM	RSMHM	SBM	SBMF	RSM	RSMHM	
Light Meat[3]													
Odor	4.9[a]	4.6[bc]	4.7[ab]	3.6[e]	4.4[cd]	4.5[bcd]	4.5[bcd]	3.5[e]	4.3[d]	4.7[ab]	4.5[bcd]	3.1[f]	.08*
Flavor	5.1	4.9	4.8	2.8	4.9	4.6	4.5	2.9	4.5	4.8	4.6	2.4	.14
Dark Meat[3]													
Odor	4.3	4.1	4.1	2.4	4.1	3.9	3.9	2.6	4.3	4.2	4.3	2.8	.08
Flavor	4.6	4.4	4.2	1.9	4.4	4.0	4.0	2.2	4.5	4.4	4.2	1.4	.12
Broth[4]													
Odor	4.4[a]	4.4[a]	4.4[a]	3.6[c]	4.4[a]	4.3[ab]	4.3[ab]	3.2[d]	[illegible][b]	[illegible][b]	4.1[b]	3.1[d]	.07*
Flavor	4.4	4.2	4.1	3.0	4.4	4.0	4.2	2.7	[illegible].2	.8	.0	2.6	.07

[1]Standard error of the means.

[2]See footnotes 1 to 4, Table 1, page 22.

[3]Seven point scale with 7 being the highest score and 1 being the lowest score. Values are means of 12 judgments by each of the 6 panelists.

[4]Five point scale with 5 being "no difference" and 1 being "extreme difference". Values are means of 12 judgments by each of the 6 panelists.

[a][b][c][d][e][f]Means within the same row sharing a common superscript letter are not significantly different at $P<0.05$. (Comparison only made if ration by storage interaction is significant.)

*Significant ($P<0.05$) interaction of ration by storage.

this score was significantly different from light meat samples taken from comparable fresh chickens fed the SBMF ration. For chickens fed the SBM, SBMF and RSM rations, odor scores for light meat showed no significant differences within short frozen storage. For long frozen storage the odor score for light meat obtained from chickens fed the SBM ration was lower ($P < 0.05$) than the odor score for comparable samples from chickens fed the SBMF ration.

There was no significant difference in odor scores for light chicken meat among the three storage periods for chickens fed either the SBMF or RSM rations. However, for light meat samples from chickens raised on the SBM and RSMHM rations, the odor scores within fresh storage were significantly higher than the scores for chickens fed these rations (SBM and RSMHM) and assigned to long frozen storage. For chickens fed the SBM ration, but not the RSMHM ration, light meat from chicken assigned to short frozen storage received lower ($P < 0.05$) odor scores than comparable samples from fresh chickens (Table 8). Ration by storage interaction did not significantly affect either the flavor of light meat or the odor and flavor of the dark chicken meat.

Broth odor also was significantly influenced by ration and storage interaction. Within each storage period, broth prepared from chickens fed the RSMHM ration received significantly lower ($P < 0.05$) odor scores than broths from all other ration by storage treatment combinations. Broths prepared from chickens fed the SBMF and RSM rations held frozen for 6 months were given significantly lower odor

scores than broths from control chickens frozen for a long time. The odor scores for broth samples prepared from chickens representing the SBM, SBMF and RSM rations and assigned to either fresh or short frozen storage were similar.

Storage treatment did not affect odor scores for broth samples prepared from control chickens (SBM ration). Chicken broth made from long frozen broilers fed the SBMF and RSM rations received lower ($P < 0.05$) odor scores than comparable broths from fresh chickens fed either the SBMF or RSM rations. Frozen storage treatments, both short and long, compared to the fresh treatment, resulted in a decrease ($P < 0.05$) in odor scores for broths prepared from chickens fed the RSMHM ration. Ration by storage interaction did not significantly influence the flavor of the broth.

Findings, for odor of light meat and broth in the present study, indicate that including 5% herring meal and adding methyl groups to a ration containing 15% Span rapeseed meal caused decreased stability in chickens during frozen storage. In contrast, odor and flavor scores for light and dark meat samples, and flavor scores for broths obtained from broilers fed the RSM rations show that these carcasses were as stable to frozen storage for 6 months as comparable samples from broilers fed the SBM (control) ration. For all palatability characteristics evaluated (for ration by storage interaction), chickens fed the SBMF ra-

tion received scores similar to those given to comparable samples from chickens representing the RSM diet. Odor scores for broth samples showed decreased stability to long frozen storage for chickens fed the RSM and SBMF rations as compared to chickens raised on the SBM ration.

SUMMARY AND CONCLUSIONS

Broiler chickens were fed four different rations; a soybean meal ration (SBM), a soybean meal ration with a fat and fiber content comparable to that of the rapeseed meal ration (SBMF), a 15% Span rapeseed meal ration (RSM) and a rapeseed meal ration with 5% herring meal, 0.1% DL methionine and 0.05% choline chloride included (RSMHM). The exact composition of the rations is given in Table 1, page 22. At eight weeks of age, the chickens were commercially killed and processed. Chickens representing each ration treatment were assigned to one of three storage treatments - fresh, short frozen storage (18 days) or long frozen storage (6 months). The effects of ration and storage treatments on the eating quality characteristics of broiler chickens were studied using objective measurements and subjective evaluations by a trained panel and a consumer panel.

Data for the effect of ration treatment indicate that feeding chickens 15% Span rapeseed meal (RSM ration) resulted in broilers with significantly lower initial raw and cooked weights than the weights of comparable chickens fed the SBM ration. Chickens fed the RSM ration had a higher ($P < 0.05$) thaw loss than larger chickens fed the SBM and RSMHM rations. Total cooking and volatile losses for chickens representing the RSM ration were significantly higher than the losses for comparable chickens fed the SBM

(control) ration. The TBA number for chickens raised on the RSM ration was higher ($P < 0.05$) than the number for comparable control chickens (SBM ration).

Inclusion of herring meal, DL methionine and choline chloride in a 15% Span rapeseed meal ration (RSMHM ration) resulted in broilers with higher ($P < 0.05$) initial raw and cooked weights than the weights of chickens fed the RSM ration, but with weights similar to those of chickens fed the SBM ration. Due to their larger raw weight, chickens representing the RSMHM ration had a lower ($P < 0.05$) thaw loss than chickens representing the RSM ration, and a thaw loss similar to that of chickens fed the SBM ration. Chickens raised on the RSMHM ration had significantly greater total cooking and volatile losses than comparable control chickens (SBM ration). The TBA number for chickens representing the RSMHM ration was higher ($P < 0.05$) than the TBA numbers for chickens from the other three rations treatments.

Chickens fed the SBMF had initial raw and cooked weights similar to those of comparable chickens fed either the SBM or RSM rations, but with significantly lower weights than chickens fed the RSMHM ration. The thaw loss for chickens raised on the SBMF diet was similar to that obtained for chickens from all other ration treatments. Total cooking and volatile losses were higher ($P < 0.05$) for chickens fed the SBMF ration than the losses for chickens fed the SBM control ration.

Data for drip loss, pH of broth, pH of cooked meat, total moisture (%), ether extract (%), monocarbonyls, shear force for light and dark meat, and water holding capacity show no significant differences attributable to ration.

A trained panel rated the flavor and overall acceptability of dark meat samples taken from chickens fed the RSM ration significantly lower than comparable samples from chickens fed the SBM ration. Flavor and overall acceptability scores for light meat samples, and odor, juiciness and tenderness scores assigned to light and dark meat samples obtained from chickens representing the RSM ration were similar to comparable samples taken from chickens fed the SBM ration. The odor of broth prepared from chickens fed the RSM ration was similar to the odor of broth made from chickens fed the SBM ration. However, the broth flavor score for samples representing the RSM ration was significantly lower than the score for comparable broths made from chickens fed the SBM ration.

Findings from the trained judges indicate that feeding broilers the RSMHM ration resulted in lower ($P < 0.05$) scores for odor, flavor and overall acceptability of light and dark meat samples than those scores assigned to comparable samples from chickens fed the other three rations. Tenderness scores for light and dark meat from chickens on the RSMHM treatment were lower ($P < 0.05$) than comparable samples from control chickens. The odor and flavor of broth samples

prepared from chickens fed the RSMHM ration were also significantly lower than broths prepared from chickens fed the other three rations.

According to trained panelists, the addition of extra fiber and fat to the SBM ration, i.e. the SBMF ration, generally resulted in light and dark chicken meat that was similar in eating quality to the meat obtained from broilers fed the SBM (control) ration. Although the differences were not significant, the flavor and overall acceptability of dark meat samples taken from chickens fed the SBMF ration were rated slightly lower than comparable samples obtained from chickens fed the control (SBM) ration, and similar to samples obtained from chickens representing the RSM ration. The odor score assigned to broth samples obtained from chickens fed the SBMF ration was similar to the score given to broths prepared from chickens raised on the SBM diet. The flavor score for broths made from chickens representing the SBMF ration was significantly lower than the flavor score for broths prepared from control chickens (SBM ration), but similar to the flavor score given broths from chickens fed the RSM ration.

A consumer panel rated the odor, flavor and overall acceptability of chicken meat from broilers raised on the SBM, RSM and RSMHM rations. Data indicate that feeding chickens the RSM ration resulted in slightly lower (but not significant) scores for all three palatability characteristics evaluated than the scores for comparable chick-

ens fed the SBM ration. Chickens fed the RSMHM ration received significantly lower scores for odor, flavor and overall acceptability than comparable chickens fed the SBM ration.

Frozen storage of broiler chickens for 18 days or 6 months had little effect on initial raw weight, cooked weight, cooking losses, pH of broth and cooked meat, percentage total moisture, percentage ether extract, monocarbonyls, and shear force values for dark meat. The thaw loss of chickens frozen 6 months was significantly higher than the thaw loss of comparable chickens frozen 18 days. The TBA number of chickens frozen and stored 6 months was lower ($P < 0.05$) than that of comparable fresh chickens and frozen chickens, stored 18 days. The shear force value for light meat samples taken from chickens frozen and stored for 6 months was lower ($P < 0.05$) than the shear force values for comparable samples from either fresh chickens or frozen chickens, stored 18 days. Water holding capacity was significantly lower for the frozen chickens stored 6 months than for fresh chickens.

Generally, trained taste panel data indicate that storage treatment did not affect the eating quality of broiler chickens. The odor of light meat samples was lowered significantly by frozen storage for either 18 days or 6 months compared to the odor of light meat obtained from fresh chickens. However, the odor score of dark meat was lower ($P < 0.05$) for short frozen chickens than for compar-

able samples from frozen chickens, stored 6 months. The odor of broth prepared from chickens frozen for 6 months was lower ($P < 0.05$) than the odor of broth made from fresh chickens. These findings seem to indicate that a loss in odor of light meat and broth occurs when broilers are frozen and stored particularly for extended periods of time.

Ration by storage interaction did not exhibit an effect on the eating quality of chickens fed the SBM, SBMF and RSM rations. Odor scores for light meat and broth samples from chickens fed the RSMHM ration tended to decrease when these chickens were frozen and stored.

Some differences in quality characteristics of chickens fed the RSM ration have been noted (decreased raw weight, difference in cooking losses and increased TBA number). In addition, data from both a trained and a consumer panel indicate that feeding 15% Span rapeseed meal (RSM ration) may have caused a slight decrease in eating quality. Thus, further studies are needed to determine whether supplementing the broiler rations with rapeseed meal results in decreased eating quality. Research is also needed to determine the effect on eating quality of broiler chickens of feeding rapeseed meal rations from new cultivars of rape, such as Tower and yellow seeded rape.

Findings from the present study indicate that although the addition of 5% herring meal, 0.1% DL methionine and 0.05% choline chloride to a ration containing 15% Span rapeseed meal improved the initial raw and cooked weights of chickens,

the eating quality of the chickens (particularly odor, flavor and overall acceptability), as rated by trained and consumer panels, was adversely affected. A further loss of eating quality (odor) resulted when the broilers representing the RSMHM ration were frozen and stored. These results would suggest that either the presence of 5% herring meal and/or higher levels of DL methionine and choline chloride than normally incorporated into broiler rations, or the interaction of the rapeseed meal with one or both of these constituents causes the production of off-odors and off-flavors in broiler meat. Further research is required to determine the cause(s) for loss in eating quality of broiler chickens fed the RSMHM ration.

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APPENDIX

Table 1 . Means and SE[1] for objective measurements from ration-storage treatment combinations.

Measurements	Ration by Storage Treatment Combinations[2]												SE
	Fresh				Frozen (18 days)				Frozen (6 months)				
	SBM	SBMF	RSM	RSMBM	SBM	SBMF	RSM	RSMBM	SBM	SBMF	RSM	RSMBM	
Thaw loss (%)[3]	-	-	-	-	2.7	2.9	3.1	2.5	3.2	3.6	4.1	3.1	.15
Initial raw wt. (g)[3]	1176.3	1149..	1114.2	1165.2	1132.0	1106.1	1110.5	1142.0	1125.9	1083.4	1066.9	1179.4	20.43
Cooked wt. (g)[3]	873.6	842.9	817.8	861.6	862.6	811.8	819.7	836.8	855.1	804.2	806.3	883.1	15.74
Cooking losses (%)[3]													
Total	25.7	26.6	26.6	26.1	23.7	26.6	26.2	26.8	23.9	25.8	24.4	25.1	.60
Volatile	19.4	20.6	21.5	20.5	18.1	21.1	21.0	21.3	18.3	20.4	19.2	19.5	.26
Drip	6.3	6.0	5.1	5.5	5.6	5.5	5.2	5.5	5.6	5.5	5.2	5.6	.42
pH[4]													
Broth	6.7	6.7	6.7	6.6	6.7	6.6	6.6	6.6	6.7	6.7	6.7	6.7	.02
Cooked meat	6.2	6.1	6.2	6.1	6.2	6.2	6.2	6.2	6.2	6.2	6.2	6.2	.02
Total moisture (%)[5]	64.7	65.2	64.5	63.9	64.2	64.4	64.4	64.6	64.5	64.8	63.9	64.4	.69
Ether extract (%)[5]	5.0	5.4	4.9	4.8	4.4	5.2	5.1	4.6	5.4	4.6	4.6	4.8	.44
TBA number[5]	8.2^{bc}	3.7^{h}	6.0^{de}	8.4^{bc}	6.4^{d}	8.8^{ab}	4.3^{gh}	7.6^{c}	5.2^{ef}	8.8^{ab}	9.5^{a}	4.8^{fg}	.27*
Monocarbonyls (mg/g fat)[6]	.11	.14	.08	.11	.12	.18	.11	.11	.20	.15	.09	.13	.02
Shear force (kg/cm core)[7]													
Light meat	2.0	2.5	2.0	2.6	2.5	2.4	2.5	2.7	1.8	1.8	2.2	1.7	.18
Dark meat	1.1	1.2	1.2	1.2	1.0	1.0	1.1	1.0	1.1	.9	1.1	.9	.14
Water holding capacity[8]	.67	.67	.67	.68	.68	.64	.64	.64	.62	.58	.64	.59	.02

[1]Standard error of the means.

[2]See footnotes 1-4, Table 1, page 22.

[3]Values are the means of 12 determinations.

[4]Values are the means of 24 determinations, two per chicken.

[5]Values are the means of 12 determinations, 2 on each of 6 chickens per ration-storage treatment combination.

[6]Values are the means of 6 determinations, 2 on each of 3 chickens per ration-storage treatment combination.

[7]Values are the means of 48 determinations, 4 per chicken.

[8]1.0 -(expressible liquid index); the larger the value, the greater the amount of liquid expressed. Values are the means of 36 determinations, 3 per chicken.

abcdefgMeans within the same row sharing a common superscript letter are not significantly different at $P<0.05$. (Comparison only made if ration by storage interaction is significant.)

*Significant ($P<0.05$) interaction of ration by storage.

Table 2. Means and SE[1] for subjective evaluations by a trained panel for light meat, dark meat and broth from ration-storage treatment combinations.

Measurements	Ration by Storage Treatment Combinations[2]												SE
	Fresh				Frozen (18 days)				Frozen (6 months)				
	SBM	SBMF	RSM	RSMHM	SBM	SBMF	RSM	RSMHM	SBM	SBMF	RSM	RSMHM	
Light Meat[3]													
Odor	4.9^{a}	4.6^{bc}	4.7^{ab}	3.6^{e}	4.4^{cd}	4.5^{bcd}	4.5^{bcd}	3.5^{e}	4.3^{d}	4.7^{ab}	4.5^{bcd}	3.1^{f}	.08*
Flavor	5.1	4.9	4.8	2.8	4.9	4.6	4.5	2.9	4.5	4.8	4.6	2.4	.14
Juiciness	4.1	3.8	4.1	3.9	3.9	3.7	3.6	3.9	4.3	4.1	4.3	4.3	.14
Tenderness	5.5	5.0	5.3	4.8	5.0	5.0	4.9	4.7	5.0	5.1	5.1	5.0	.12
Overall acceptability	5.1	4.8	4.9	2.7	4.7	4.5	4.5	2.9	4.4	4.6	4.6	2.4	.14
Dark Meat[3]													
Odor	4.3	4.1	4.1	2.4	4.1	3.9	3.9	2.6	4.3	4.2	4.3	2.8	.08
Flavor	4.6	4.4	4.2	1.9	4.4	4.0	4.0	2.2	4.5	4.4	4.2	1.4	.12
Juiciness	4.7^{ab}	4.7^{ab}	4.6^{bc}	4.5^{c}	4.5^{c}	4.6^{bc}	4.5^{c}	4.3^{d}	4.5^{c}	4.6^{bc}	4.8^{a}	4.7^{ab}	.05*
Tenderness	4.9	4.9	5.0	4.7	5.2	5.1	5.1	4.9	5.2	5.3	5.0	5.1	.06
Overall acceptability	4.5	4.3	4.1	1.9	4.4	4.3	4.1	2.0	4.6	4.3	4.3	2.1	.11
Broth[4]													
Odor	4.4^{a}	4.4^{a}	4.4^{a}	3.6^{c}	4.4^{a}	4.3^{ab}	4.3^{ab}	3.2^{d}	4.5^{a}	4.1^{b}	4.1^{b}	3.1^{d}	.07*
Flavor	4.4	4.2	4.1	3.0	4.4	4.0	4.2	2.7	4.2	3.8	4.0	2.6	.07

[1] Standard error of the means.

[2] See footnotes 1-4, Table 1, page 22.

[3] Seven point scale with 7 being the highest score and 1 being the lowest score. Values are means of 12 judgments by each of the six panelists.

[4] Five point scale with 5 being "no difference" and 1 being "extreme difference".

abcdef Means within the same row sharing a common superscript letter are not significantly different at $P<0.05$. (Comparisons only made if ration by storage interaction is significant.)

*Significant ($P<0.05$) interaction of ration by storage.

DATE: _____

JUDGE: _____

SAMPLE NO. _____

N.B. IF ANY SCORE IS A 3 OR LESS, PLEASE GIVE REASON WHY.

	7	6	5	4	3	2	1
Odor	very full, rich, chickeny	full, rich	good, full	good, faint	Weak or slightly unpleasant, slightly stale	lacking chicken odor, stale, unpleasant	very unpleasant
Juiciness (3 chews)	extremely juicy	very juicy	juicy	neither dry nor juicy	dry	very dry	too dry to swallow easily
Flavor (after cube completely masticated)	very full, rich chickeny	full, rich	good, full	good, faint	weak, slightly unpleasant slightly stale	lacking chicken flavor - unpleasant, stale	very unpleasant
No. of chews							
Tenderness score	extremely tender	very tender	tender	slightly tough	tough	very tough	extremely tough
Overall Acceptability	extremely desirable	desirable	moderately desirable	acceptable	slightly undesirable	undesirable	extremely undesirable

Comments:

Figure 1 . Scorecard used for subjective evaluation of light and dark chicken meat by a trained taste panel.

Figure 2. Instructions given to the trained judges for subjective evaluation of chicken meat samples.

INSTRUCTIONS TO JUDGES FOR SENSORY EVALUATION OF POULTRY

Score each palatability characteristic in the order listed on the scorecard by marking an "X" in the box under the column headed 7, 6, 5, 4, 3, 2 or 1. Try to judge each sample individually without consciously comparing it with other samples. Consider carefully the descriptive terminology for specific scores within the range of 7 to 1 in deciding upon the score to assign each palatability characteristic.

Scoring for Odor - Aroma or odor is the quality of a substance which affects the sense of smell. Using 1 cube of chicken, bring the sample to directly beneath the nose and inhale quickly 3 times. Then, record the score within a range of 7 to 1, which describes your impression of the aroma. Comments are welcomed, and a list of descriptive terms for odor are given to assist you.

Scoring for Flavor and Juiciness - Using the same cube as above, record a score for flavor and another for juiciness within a range of 7 to 1 that describes your impression of the sample.

Juiciness - is the amount of moisture in mouth and remaining in the chicken after 3 chews. Anchors are provided to standardize the scores within range. If necessary use them to refresh your memory.

Flavor - is the intensity of the chickeny flavor remaining in the mouth after complete mastication. Again, the list of descriptive terms might help you explain the flavor experienced.

Scoring for Tenderness - Use the other cube of chicken to score tenderness. Place cube in mouth so that molar teeth bite down the grain. Count the number of times you chew the 1 cm cube of chicken before swallowing. Chew until the cube of chicken is completely masticated, then swallow. (This does not mean that you chew the sample just "until you can swallow it comfortably".) Record the number of chews required to masticate the cube. Mark a score from 7 to 1 that describes your impression of the tenderness of the cube. Consider the scorecard for descriptive terms for specific scores within the range of 7 to 1, using your chew range cards.

Overall Acceptability - Record a score that describes your impression of the general desirability of the sample. This is not a total score, i.e. it is not a score obtained by adding the scores for the other factors listed on the scorecard. The score for overall acceptability is within the range of 7 to 1, the same as for each of the other factors listed on the scorecard.

Comments - Comments about a sample and/or explaining your reason for assigning a particular score are helpful.

Take Your Time - to score each sample. Water is provided for rinsing your mouth between samples. Rinse between samples. It is not necessary to swallor the cube used to score flavor and juiciness.

Before you turn in your scorecards, check to be sure that you have:

(a) scored each palatability characteristic

(b) recorded the number of chews required to completely masticate the sample.

LIST OF DESCRIPTIVE WORDS

AROMA

meaty-brothy
acidic
ammonia-like
sulfury
rancid
stale
fishy
acrid, burnt
chickeny
foreign

FLAVOR

acidic, sour
metallic
eggy, sulfury
bitter
grainy, feedy, grassy
bland, little flavor
real chicken, chickeny
off-flavor, odd
rancid, stale
greasy, oily
fishy
burnt, acrid
salty
sweet
foreign

Figure 3. Descriptive terms provided to trained panelists for subjective evaluation of the odor and flavor of chicken meat and broth.

DATE: _____

JUDGE: _____

BROTH - Multiple Comparison of Odor and Flavor

INSTRUCTIONS: You have been given a reference sample (R). Please score each of the coded samples in comparison with the reference sample in the order in which they appear on this scorecard.

For Odor Evaluation: Smell each of the samples by bringing covered beaker to nose, lifting off cover, and placing beaker directly under nose. Then after resmelling R sample score the degree of difference that exists.

For Flavor Evaluation: To taste broth take 1 teaspoon of liquid and place it in mouth, bringing it immediately to the back of the tongue, hold in mouth for 10 sec. then swallow. Score the difference in flavor that exists. Water is provided to rinse mouth between samples. Remember taste R first.

Sample No.	None	Slight	Moderate	Much	Extreme	Explain Any Difference	None	Slight	Moderate	Much	Extreme	Explain Any Difference
Comments:												

Figure 4. Scorecard for subjective evaluation of chicken broth by the trained taste panel.

Figure 5. Questionnaire distributed to the participants of the consumer study.

QUESTIONNAIRE

NAME: _____

ADDRESS: _____

1. Are you gainfully employed outside the home?
   Yes _____ No _____

   If yes, what is your occupation? _____

2. Please indicate the age group to which you belong as of your last birthday:

   _____ 24 and under

   _____ 25 - 34

   _____ 35 - 44

   _____ 45 - 54

   _____ 55 and over

3. How many people are there in your family?

   _____ one, _____ two, _____ three, _____ four,

   _____ five, _____ six, _____ seven, _____ over seven.

4. How many of these people are:

   _____ under 6 years

   _____ 7 - 12

   _____ 13 - 17

   _____ 18 - 24

   _____ 25 - 34

   _____ 35 - 44

   _____ 45 - 54

   _____ 55 and over

5. What kind of work does the main wage earner do? Please describe his or her work as specifically as you can: we need to know the type of work done, but not the name of the company or business.

   For example: car mechanic at a garage; salesclerk at a store; teach in a high school; salesman for a book company; operates a farm of 160 acres; unemployed.

   _____

   _____

   _____

6. Which of the following statements best describes the working situation of the person you named main wage earner. (Check the one which best applies to your situation.)

_____ works for someone; does not manage the business or farm.

_____ works for someone; does manage the business or a main part of it.

_____ owns a business (or farm), but hires someone else to manage it.

_____ owns and manages his or her own business or farm.

_____ retired.

7. In general, does your family like chicken?

_____ like very much, _____ like, _____ neither like nor dislike, _____ dislike, _____ dislike very much.

8. Approximately how often do you serve chicken to your family?

_____ 2 or more times/week

_____ about once a week

_____ 2 or 3 times/month

_____ about once a month

_____ less than once a month

_____ not at all in the past 12 months

9. Where do you usually obtain the chickens that you serve to your family?

_____ raise and kill your own

_____ from a private seller

_____ from a local store

_____ other, please specify _____

Figure 6. Instructions provided for subjective evaluation of chicken by a consumer panel.

INSTRUCTIONS

You have been asked to participate in a study on broiler chickens currently being conducted at the University of Alberta.

1. Carefully fill out the questionnaire.

2. Read through the instruction sheet.

We would appreciate if you could return the completed questionnaire and scorecard to _____ your District Home Economist by December 19, 1975.

You have been given three frozen chicken halves to thaw, cook, taste and evaluate. Each chicken is individually coded with a metal tag which has a four digit code number on it. This metal tag is attached to the wing of the chicken and should not be removed so that you can identify each chicken when you are tasting it.

Procedure:

1. Thaw the chicken halves in their packaging. This will take approximately 24 hours in the refrigerator; 5-7 hours at room temperature. (These chickens must be used within 2 days of thawing.)

2. Prior to cooking, remove the chicken from the plastic bag. If you are not used to cooking and eating chicken without salt, a small amount of salt may be used. PLEASE DO NOT SEASON THE CHICKEN with other spices or herbs before or after cooking, as this could tend to camouflage flavor and odors.

3. Wrap each thawed chicken separately in aluminum foil, making sure that each chicken is securely wrapped.

4. Place the three foil-wrapped chicken halves on a rack in a large pan with sides (i.e. cookie sheet, cake pan, etc.) or on a broiler pan.

5. Bake at 350°F for approximately 3/4 to 1-1/2 hour, depending on the size of the chicken, or until the chicken meat is cooked to the desired degree. Because of the method used for cooking, the skin will not brown, so do not use this as your indication of doneness. Guides which may be used to indicate doneness include:

   a) Leg should move easily at the hip joint.
   b) Meat should be soft when the chicken is cooked.

The chickens may be browned at the end of the cooking period by pulling the foil back and raising the oven temperature to 425° for about 15 minutes.

*When the chickens are cooked, they should be evaluated using the scorecard provided. Please put date and name on the scorecard. The meat from each of the chickens should be smelled, tasted and scored ONE AT A TIME FOLLOWING THE CODE NUMBER ORDER LISTED ON THE SCORECARD. Refer to the wing tag for the code number. First smell, then taste each sample. Using the scorecard provided put a large "X" in the box which describes your opinion of the odor or aroma, the flavor, and the overall acceptability. Any comments you may have are welcome. After all three chickens have been individually evaluated, rank them in order of your preference. Give 1. to the most preferred, 2. to the next best, and 3. to the least preferred.

Before returning the questionnaire and scorecard to _____, your local District Home Economist -

1. Please check that your name and address as well as the date are on the top of the scorecard, and
2. make sure the questionnaire has been completely answered.

Instructions to one third of consumers -

* When the chickens are cooked, they should be evaluated using the scorecard provided. Please put date and name on the scorecard. The meat from each of the chickens should be smelled, tasted and scored ONE AT A TIME WRITING THE CODE NUMBER IN THE SPACE PROVIDED AS YOU TASTE EACH CHICKEN. Refer to the wing tag for the code number.

Have you any suggestions, favorable or unfavorable comments or complaints that you would like to make to the Poultry Producers of Alberta regarding the poultry currently available to consumers?

Are there any particular difficulties that you encounter in cooking poultry?

A space is provided for these at the bottom of the scorecard.

Thank you for participating in this study. We hope you and your family enjoy your chicken dinner! If you are interested in receiving information on the results of this study, please contact me, Carol Steedman, at the University of Alberta, School of Household Economics, Foods and Nutrition Division, Edmonton, or your local District Home Economist after May 15, 1976.

SCORECARD FOR CHICKEN

DATE: ____________________ NAME: ____________________

ADDRESS: ____________________

CODE NO. ____	5	4	3	2	1
Odor or Aroma	like very much	like	neither like nor dislike	dislike	dislike very much
Flavor	like very much	like	neither like nor dislike	dislike	dislike very much
Overall Acceptability	very good	good	acceptable	poor	very poor

Comments

CODE NO. ____	5	4	3	2	1
Odor or Aroma	like very much	like	neither like nor dislike	dislike	dislike very much
Flavor	like very much	like	neither like nor dislike	dislike	dislike very much
Overall Acceptability	very good	good	acceptable	poor	very poor

Comments

CODE NO. ____	5	4	3	2	1
Odor or Aroma	like very much	like	neither like nor dislike	dislike	dislike very much
Flavor	like very much	like	neither like nor dislike	dislike	dislike very much
Overall Acceptability	very good	good	acceptable	poor	very poor

Comments

Please rank the samples according to your preference.

		Code No.
1.	most preferred	________
2.		________
3.	least preferred	________

Suggestions, Comments or Complaints for Alberta Poultry Producers.

Difficulties encountered in cooking poultry.

Figure 7. Scorecard for subjective evaluation of chicken meat by a consumer panel.

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