FLAVOR STUDIES

Origin of Chicken Flavor

ELDON L. PIPPEN, AGNES A. CAMPBELL, and IVA V. STREETER

Western Utilization Research Branch, Agricultural Research Service, U. S. Department of Agriculture, Albany 6, Calif.

Poultry flavor was studied to increase knowledge of its chemical nature. Such information will provide a sound basis for measures that assure maximum retention and development of flavor, particularly in commercially produced poultry products where processing and storage conditions may affect flavor. Determination of the relative contribution of gross parts or fractions of the carcass to flavor of broth showed that fat contributes to the aroma of broth, but is otherwise of minor importance to its flavor. Meat was a better source of flavor than bones, skin, or a composite of all three parts. Precursors of flavor are readily extracted from cut-up raw meat by cold water. Conclusions concerning the practical implications of these laboratory results must await an extension of the study to include other variables that would be encountered under practical conditions.

PREFERENCE FOR POULTRY, upon which maintenance and expansion of the poultry industry depend, is generally acknowledged to rest to a major degree on the relatively intangible quality of flavor. Considerable importance is attached, therefore, to questions from industry and the consuming public on adequacy of flavor in canned poultry products and in the commercial broiler. The search for better methods of developing and retaining poultry flavor has been handicapped by lack of fundamental knowledge on chemical constituents of poultry flavor, their precursors, and the reactions that produce and destroy flavor. Studies designed to provide such knowledge have been initiated at this laboratory, and as a necessary preliminary step, experiments were conducted to establish the contribution of gross parts of chicken carcass to flavor.

Howe and Barbella (*6*) pointed out the complex nature of meat flavor and lack of evidence concerning its chemical characteristics. Salomon (*7*) stated that raw fresh meat has no flavor and attributed the flavor of cooked meat to amino acids liberated on cooking. Crocker (*5*) concluded that bones, fat, juices, and extractives of beef muscles are relatively unimportant contributors to beef flavor. Bouthilet (*1–4*) presented evidence that fat is a minor contributor to chicken flavor and that precursors of flavor are extractable by polar solvents. However, Crocker and Bouthilet apparently did not compare the flavor in their fractions with that in control samples; thus interpretation of their results is somewhat difficult.

Data presented in this paper indicate that poultry flavor is derived mainly from the meat and particularly from the portion that is extractable with cold water, to a lesser extent from bones and skin, and scarcely at all from fat. Results reported here, unless otherwise stated, are based on flavor of the broth made from the chicken. Broth rather than chicken itself was tasted in this phase of the investigation because it permitted employment of certain experimental techniques such as distillation, flavor dilution, and concentration, which would be difficult or impossible to use on the meat itself. Preliminary results show that factors affecting flavor of broth also have an important effect on flavor of meat.

Table I. Effect of Large Differences in Amount of Fat Cooked with Chicken Meat on Flavor and Odor of Aqueous Broth

Category	Mean Scores[a] Flavor	Odor
Fat-rich sample	6.5	6.2
Fat-poor sample	5.8	5.2

[a] Score of 10 = strong flavor or odor; 0 = no flavor or odor. Differences between mean scores were not significant.

General Procedures

Source and Processing Of Chickens Unless specified otherwise for individual experiments, material for studies was obtained from commercially available yearling colored chickens which were eviscerated warm or after chilling overnight, and were stored in polyethylene bags at −30° F. prior to use. When parts of the carcass were separated, each fraction was thoroughly mixed before samples were withdrawn for experiments. This procedure avoided the possibility of bird-to-bird variation when more than one carcass was employed. In general, meat used to prepare broth contained both white and dark meat in the proportion noted when they were cut from eviscerated carcasses. In this study the term "meat" is used to indicate chicken muscle freed from skin, bone, and visible extramuscular fat.

Preparation Of Broth To prepare broth, distilled water equal to one half the weight of the sample to be cooked was added to the sample in a stainless-steel container. No seasoning was used. With a lid in place, the container was heated with a gas flame, with occasional stirring, until gentle boiling started. Cooking time was calculated from the first appearance of boiling until heat was removed. At the end of the cooking period, distilled water was added to compensate for weight lost by evaporation. Broth was

Table II. Evaluation of Broths Prepared from Freeze-Dried Chicken Meat

(Treatments before cooking unextracted (control), petroleum ether–extracted with fresh fat added back, and petroleum ether–extracted)

Treatment	Mean Score[a] Flavor	Odor
Unextracted (control)	6.0	6.5
Extracted with fat added	6.0	6.2
Extracted	5.3	5.3
Least significant difference		
5% level	0.9	0.9
1% level	...	1.2

[a] Score of 10 = strong flavor or odor; 0 = no flavor or odor.

then decanted into a separatory funnel from which the aqueous phase was drawn. Routinely, unless otherwise specified, only the aqueous phase of broth was tasted. This was done primarily to eliminate prejudices that might arise from visible differences in the amount of fat floating on the broth.

A cooking time of 3 hours, unless otherwise stated, was used to prepare broth throughout the study. In practice, this period was subject to an error of about ±10 minutes, owing to differences in sample size or rate of application of heat. Two experiments were therefore conducted to determine whether such small differences could result in significant differences in flavor and odor intensity. In one experiment, intensity of flavor and odor was evaluated in broth prepared from separate similar portions of meat cooked for 0.5, 1.5, and 3 hours, respectively (3 replications, 24 judgments). In similar experiments the cooking times were 1, 2, and 4 hours, respectively (6 replications, 48 judgments). Analysis of results showed that a difference of 1.5 hours was necessary to cause a significant difference in odor intensity and in such instances broth from the sample cooked the longest time was judged to have the most intense aroma. After at least 1 hour's cooking, differences of 1 to 3 hours resulted in no significant change in flavor intensity. These results show that a possible error of ±10 minutes in a nominal cooking time of 3 hours would not be expected to affect significantly flavor or aroma intensity of broth. Therefore it can be concluded that the control of cooking conditions was adequate.

Flavor Evaluation Chicken flavor was evaluated by a taste panel of eight judges, who evaluated each replicate from each experiment. Panel members consisted of employees of this laboratory who were trained and selected following preliminary experiments in which they evaluated chicken broth and demonstrated an ability to distinguish correctly between broth samples known to differ in strength by 17%. Judges were asked to evaluate intensity of flavor and, in an effort to gain some information concerning the nature of the volatile composition, were often asked to evaluate intensity of chicken odor separately. In most cases the judges were asked to score samples within a range from 10 points for strong chicken flavor or odor to 0 for no flavor or odor. In some instances samples were ranked. For purposes of this study, flavor is defined as the stimuli given by the sample to the taster's receptors, both oral and nasal, when the sample is consumed orally; odor is defined as the stimuli evoked when a sample is smelled only—i.e., only volatile components reach the receptor of the judge. Broth samples were served hot in 50-ml. beakers; samples to be judged for odor were served in separate beakers which were kept covered until evaluated. Prejudices which might arise from

Table III. Comparison of Carcass (Composite) and Its Parts as Sources of Flavor

Category	Mean Score[a] Flavor	Odor
Meat	7.6	7.0
Composite	6.3	5.9
Bones	3.9	3.9
Skin	2.5	3.0
Least significant difference		
5% level	...	0.9
1% level	1.1	1.2

[a] Score of 10 = strong flavor or odor; 0 = no flavor or odor.

differences in color were obviated by either blindfolding the judges or matching the color with food dye. Significance of results was determined by accepted statistical methods (*8*).

Experimental Work and Results

Chicken Fat as a Source of Flavor At the outset it was desirable to establish the contribution of fat to flavor, and particularly to determine whether the upper fatty layer of broth could be discarded and the aqueous phase alone served to the taste panel, without invalidation of taste-panel data. In the first experiment to

Table IV. Effect of Extracting Cut-Up Chicken Meat with Cold Water

Treatment of Meat	Mean Score[a] Flavor[b]	Odor[b]
Control	7.0	5.3
Water extracted[c]	3.2	4.5

[a] Score of 10 = strong flavor or odor; 0 = no flavor or odor.
[b] Differences in mean scores are significant at 1% level.
[c] Meat subjected to 4 extractions at 2° C. for 2.5, 2.5, 15.8, and 1.8 hours, respectively.

test this point, two samples of chicken meat were cooked, one freed as completely as possible from visible extramuscular fatty tissue, the other containing about twice the amount of depot fat that would normally accompany the meat in the carcass. The average ratio of weight of fat in the fat-rich meat to that in the fat-poor meat was 19. Average panel scores for the aqueous phase of the broth, from four replications of this comparison (Table I), showed no significant difference in flavor or odor between fat-rich and fat-poor samples.

Further evidence of the role of fat in flavor development was obtained by comparing broth from three meat samples: a control sample with its normal amount of fat in place in the muscle fiber, a sample stripped of its fat content by solvent extraction, and the stripped sample, restored to its original fat content by addition of freshly rendered depot fat. Diced chicken meat was dried from the frozen state and the fat extracted with purified petroleum ether (boiling point 30° to 60° C.). Last traces of solvent were removed with a mechanical vacuum pump connected to the meat sample through an alcohol–dry ice trap. The fat added to the third sample was obtained by freeze-drying fresh depot fat, warming on a steam bath, and pressing out the clear liquid fat through cheesecloth. Tests of three series of broths prepared from the samples (Table II) showed no significant flavor differences. This is convincing evidence that fat is of little importance as a flavor source. With respect to odor or aroma, samples in this experiment containing fat received significantly higher scores than the nonfat samples, which could mean that in this respect fat may be of some importance. Further work on this point would be desirable. These experiments also indicate that chicken

fat is a poor solvent for chicken flavor. This conclusion was supported by tasting fat skimmed from four broth samples. Average panel score for the fat was less than 1.0, compared to a value of 5.2 for the aqueous phase on a scale of 10 for strong and 0 for no flavor.

Table V. Presence of Flavor Precursors in Cold-Water Extract of Chicken Meat

Source of Broth	Mean Score[a] Flavor[b]	Odor[c]
Control (unextracted meat)	0.40	0.69
Water-extracted meat plus extract	0.48	0.19
Aqueous extract	−0.21	−0.51
Water-extracted meat	−0.92	−0.58

[a] Mean scores not based on 10-point scoring system, but represent values obtained by conversion of ranks to scores. Intensity of flavor or odor corresponds to mean score, with samples rated at higher scores being judged to have more intense flavor or odor.

[b] All differences in mean scores for flavor are highly significant, except that between control and samples of water-extracted meat plus extract which is not significant.

[c] All differences in mean scores for odor are highly significant, except that between categories of aqueous extract and water-extracted meat, which is not significant.

Bones, Skin, Meat Investigation of the entire carcass was necessary in order to learn whether or not the carcass itself or one of its parts serves as the best source of flavor. The carcass was divided into fractions consisting of bone, meat, and skin, while the entire carcass was represented by a composite consisting of these combined in natural proportions. Three birds were used to obtain the fractions for each replicate. Results of evaluation of broth from three replicates are presented in Table III. For flavor, highly significant differences were obtained between all treatments; the meat received the highest score, followed by the composite, bones, and skin in decreasing order. For odor, similar results were obtained. These results, in addition to supplying evidence that most of the flavor is derived from the meat, also show that when the three components are cooked together they do not by interaction produce a flavor superior to that of the meat alone.

Light Compared To Dark Meat As a follow up, another experiment was conducted to determine whether there is a detectable difference in amount of flavor extractable from light and dark meats. Analysis of the data from three experimental replicates showed no significant difference in either flavor or odor of broths obtained from light and dark meat.

Effect of Extracting Raw Chicken With Cold Water Further attention was given to meat, to see whether substances responsible for its flavor could be extracted with cold water. In the first experiment, three pairs of broths were prepared from raw chicken meat, unextracted and extracted in cold water. For the first extraction, distilled water at tap-water temperature was added to diced meat, in amount sufficient to cover the meat. The water-covered meat and control were then placed in the refrigerator. Subsequent extractions were accomplished by decanting water from diced meat, squeezing it by hand, and then adding more distilled water which had been chilled to the temperature of the refrigerator. In this experiment, the sample was extracted four times with soaking periods of 2.5, 2.5, 15.8, and 1.8 hours, respectively. Results (Table IV) show that the water-extracted chicken meat had lost much of its ability to impart flavor to broth. Therefore, important precursors of chicken flavor were either removed or altered by the cold-water extraction.

These results are of such basic importance that another experiment was conducted not only to verify them but also to determine whether flavor is present in the aqueous extract and to establish the effect of extraction on flavor of meat itself. To obtain this information, broths were prepared in the following categories: control sample of meat, meat extracted with cold water to which the extract was subsequently added, meat extracted with water, and aqueous extract of meat. Diced meat (3 kg.) was divided into three equal portions. One portion was a control, while the other two were extracted with cold water essentially as described above. The aqueous extracts were frozen to the insides of glass flasks and concentrated by freeze-drying to a point where volume of thawed concentrate amounted to 50 to 100 ml. The meat was stored at −30° F. (−34.4° C.) during concentration of extracts. Weights of meat observed prior to extraction were used as a basis for calculating the amount of water to add for cooking. To cook the concentrated aqueous extract, it was first diluted to 800 ml.; after cooking it was diluted to the same volume of broth as the control sample. Cooked meat from these experiments was placed in polyethylene bags and stored at −30° F. until removed for evaluation. For serving to judges, the meat was thawed, heated in double boilers, and served on hot dishes. Judges were asked to evaluate flavor only.

Results from eight replications (Table V) show that broth prepared from the water-extracted meat again received significantly lower scores for both flavor and odor than that from the control, in confirmation of results described above. In addition, it is apparent that the judges made no distinction between broth from the control and that from the water-extracted sample plus extract. More flavor was present in broth made from extract than in broth made from water-extracted meat. This is clear evidence that the aqueous extractives of raw chicken meat contain substances which are important precursors of chicken flavor. Results for odor evaluation of broth are not so clear, possibly because of the inherent difficulty of this type of evaluation or loss or alteration of aroma-producing constituent(s) during concentration of flesh extracts. Nevertheless, the data show a significant difference in odor between broth from the water-extracted samples plus extract and that prepared from the water-extracted meat, thus showing that aqueous extract also contains substances contributing to aroma intensity.

Results of evaluation of meat from six replicates of this experiment (Table VI) showed that the judges rated the control and the water-extracted samples plus extract at about the same level of flavor intensity, whereas the sample of meat that had been extracted with water received a significantly lower score. Thus cold-water extractives of chicken meat are not only important to the flavor of broth but also contribute substantially

Table VI. Importance of Cold-Water Extractives of Raw Chicken Meat to Flavor

(Evaluation of residual flavor in samples of meat from which broth hos been prepared)

Pretreatment of Meat	Mean Score, Flavor[a]
None (control)	4.7
Water-extracted plus extract	4.6
Water-extracted	1.6

[a] Score of 10 = strong flavor; 0 = no flavor. Least significant difference, 1% level = 0.9.

Table VII. Effect of Soaking Half Carcasses in Ice Water

Category	Mean Score, Flavor[a] 18-hour soak	5-hour soak
Control half	5.7	5.6
Soaked half	4.4	4.0
Least significant difference, 1% level	1.1	1.5

[a] Score of 10 = strong flavor; 0 = no flavor. Differences in mean scores for odor intensity not significant.

to flavor of the meat itself. These results also show that a correlation may be expected between flavor as evaluated in the broth and the meat from which it was prepared.

Soaking in Ice Water

The experiments described above clearly demonstrated that flavor precursors can be extracted from raw chicken meat with water under the laboratory conditions used. As an obvious corollary, two preliminary experiments were conducted to determine how much, if any, flavor loss resulted from the general practice of chilling poultry in slush ice or thawing in water. Half carcasses were used, one half as a control and the other soaked in ice water. The average weight of ice water used for each carcass half was 9 kg. Unsoaked halves were stored in polyethylene bags at 2° C. during the soaking period. Ratios of water to meat used for cooking were based on weights observed before the soaking period. Immersion times for the two experiments were 18 hours in one case and 5 hours in the other. For the former there were six replications; for the latter, three. The results (Table VII) show that broth from the control halves contained significantly more flavor than broth from the halves chilled in ice water. While these results indicate a flavor loss as a result of immersion in ice water, it is emphasized that these experiments were carried out on previously frozen birds. Consequently, conclusions concerning the importance of flavor loss in the commercial chilling of poultry in ice water will require additional experiments with freshly slaughtered unfrozen birds.

Literature Cited

(1) Bouthilet, R. J., *Food Research*, **15**, 322 (1950).
(2) *Ibid.*, **16**, 137 (1951).
(3) *Ibid.*, p. 201.
(4) Bouthilet, R. J., *Food Technol.*, **3**, 118 (1949).
(5) Crocker, E. C., *Food Research*, **13**, 179 (1948).
(6) Howe, P. E., and Barbella, N. G., *Ibid.*, **2**, 197 (1937).
(7) Salomon, Max, *Food Manuf.*, **18**, 91 (1943).
(8) Snedecor, G. W., "Statistical Methods," Ames, Iowa, Iowa State College Press, 1946.

Received for review November 23, 1953. Accepted March 6, 1954. Presented before the Division of Agricultural and Food Chemistry at the 124th Meeting of the AMERICAN CHEMICAL SOCIETY, *Chicago, Ill.*

FRUIT COLOR STABILITY

Interaction of Ascorbic Acid, Riboflavin, and Anthocyanin Pigments

DAN E. PRATT, CHARLES M. BALKCOM[1], JOHN J. POWERS, and LIONEL W. MILLS[2]
Food Technology Department, University of Georgia, Athens, Ga.

This study was made to ascertain the effect of ascorbic acid and riboflavin on the loss of color in anthocyanin pigments of strawberry juice and to evaluate the reliability of polarographic methods for quantitatively determining ascorbic acid and riboflavin in mixed solutions. Spectrophotometric determinations demonstrated that as the length of storage was increased there was a corresponding increase in the amount of brown color present. The greatest losses of both ascorbic acid and riboflavin were in samples containing ascorbic acid, riboflavin, and anthocyanin pigments. The retention of riboflavin was greatest when stored in pure solutions; the retention of ascorbic acid was greatest when stored alone or in mixtures containing riboflavin. Ascorbic acid and riboflavin were determined polarographically, with mean errors in the calibration curves of 1.38 and 1.84%, respectively. The results confirm the findings of others that ascorbic acid and anthocyanin pigment react, causing destruction of the pigment, and indicate that riboflavin may contribute to the instability of anthocyanin pigments.

THE STABILITY OF THE COLORED PIGMENTS of strawberry juice has been shown to be affected by the redox constituents present (*6*). Beattie, Wheeler, and Pederson (*2*) suggested that an interaction existed between ascorbic acid and the pigments. Similar observations were made by Pederson, Beattie, and Stotz (*20*) and Nebesky, Esselen, McConnell, and Fellers (*18*). Spectrophotometric determinations by Esselen, Powers, and Woodward (*8*) and Esselen, Powers, and Fellers (*7*) demonstrated that slight color changes were brought about by the use of ascorbic acid in fruit juice, but that the changes in color and flavor were not objectionable.

In a recent article Meschter (*16*) discussed the significant factors to be considered in studying the color deterioration of strawberries. Bauernfeind (*1*) has recently reviewed the uses and limitations of ascorbic acid as an antioxidant in foods.

The purpose of the study reported herein was to determine whether another redox constituent found in many foods—riboflavin—might affect the stability of anthocyanin pigments. Riboflavin has been shown (*19*) to accelerate the oxidation of ascorbic acid. The authors were of the opinion that an interaction might exist among ascorbic acid, riboflavin, and anthocyanin pigments. Strawberries usually contain about 0.07 mg. % riboflavin and 60 mg. % ascorbic acid (*24*).

[1] Present address, Hills Bros. Co., Woodbury, Ga.
[2] Present address, Welch Grape Juice Co., Westfield, N. Y.