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Effect of Processing and Cooking on Certain Nutrients in Fowl

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CONTENTS

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INTRODUCTION

A popular method of cooling eviscerated poultry carcasses in commercial use at the present time is that of chilling in a tank of air-agitated slush ice. Chilling by this method prevents dehydration and discoloration and yields birds with a bright, unblemished, appearance. As practiced commercially, however, this method is not readily controlled and, often, carcasses are allowed to remain in the chilling tubs for periods of time longer than necessary for cooling. Some workers (Pippen *et al.* 1954) have reported loss of flavor in water-cooled poultry; others (Pippen and Klose, 1955), loss of inorganic substances. The quantity of inorganic constituents in leach water increased with the length of time the carcasses were soaked (Hurley *et al.* 1958 and Fromm and Monroe, 1958).

The purpose of this study was to determine if in water-chilled fowl there was a loss of the water-soluble vitamins, thiamine and riboflavin, and what effect cooking would have on the retention of thiamine, riboflavin, methionine, and lysine in such fowl.

EXPERIMENTAL PROCEDURE

Nineteen month-old fowl, weighing between 3 pounds and 3 pounds 13 ounces eviscerated, were supplied by the Poultry Husbandry Department of the University of Missouri. The birds had been raised under similar conditions and were fed the same complete diet to assume, insofar as possible, similar composition of muscle tissue. They were killed by piercing the brain and severing the jugular vein to allow complete bleeding. They were then scalded in water at 140°F, dressed on a "Greenbriar Roto-Line" picker and eviscerated while warm.

Some of the carcasses were allowed to air-chill in a cold room at 32°F; others were placed into 22 gallon galvanized containers containing distilled water held at 32°F. The containers were kept in a circulating air cooler and were equipped with a means of aerating the water to hasten cooling of the carcasses. Chilling periods were 3 hours and 18 hours long. Carcasses removed from the ice water were allowed to drain for 15 minutes. The birds were split in half

[1]Includes data from thesis submitted by Linda Whitworth in partial fulfillment of the requirements for the degree of Master of Science in the Graduate School of the University of Missouri.

[2]This bulletin is a report of the Missouri Agricultural Experiment Station, Home Economics Research Project 314, and Poultry Husbandry Research Project 313.

along the backbone in such a manner that the left side had the backbone and was larger than the corresponding right side. The ready-to-cook carcasses were weighed before and after being split. Each half was placed into a Cryovac bag and stored at -10°F.

Cooking

The carcasses were thawed in a refrigerator at 35° to 40°F for 16 to 18 hours and the defrosting was completed at room temperature the following morning for approximately 1 to 2 hours. The birds which had been chilled in ice water slush were easily identified because they had large flakes of ice adhering to the visceral cavity. The ice was removed before the birds were completely thawed. Because of this slow thawing, there was no drip from any of the carcasses. The left side was cut crosswise to separate the light and dark meat. Each section was placed into a separate "basket" made from heavy aluminum foil which was made to fit on the rack of a large pressure saucepan.[3] Distilled water (600 ml) was placed in the pan under the rack and the fowl was cooked at 10 pounds pressure for 35 minutes according to the instructions of the manufacturer of the pressure saucepan. Preliminary work had indicated that these conditions produced meat that was well cooked; therefore, this procedure was followed in the cooking of all samples.

The cooked chicken was allowed to drain and cool at room temperature for 15 minutes before being weighed. Broth from each "basket" was poured into separate beakers and placed in the refrigerator to allow the fat to rise to the surface and solidify. The fat was removed, weighed, and discarded; the broth was strained and the volume measured in a graduate cylinder. Broth samples were stored in tightly sealed brown bottles at -20°F under toluene.

Preparation of Samples for Analysis

While the left side of a bird was cooking, the corresponding right side was being prepared for analysis of uncooked poultry meat. In all samples, the skin, visible fat and connective tissue were discarded. Light meat was obtained from the breast and wing, dark meat from the leg and thigh. The raw and cooked, light and dark, meats were wrapped separately in heavy aluminum foil and frozen at -20°F. While still in the frozen state, the poultry meat was passed through a hand-operated food grinder. Each sample was ground once using a coarse tooth cutter, then twice through a fine tooth cutter and mixed throughly between grindings to assure homogeneity. This operation took place in a walk-in freezer at 0°F. The frozen meat, which was nearly a powder in consistency, was wrapped in heavy aluminum foil and stored in a freezer at -20°F until assayed. The advantages of handling meat samples in this manner were primarily to prevent loss of moisture and to facilitate grinding. For analyses, aliquots were withdrawn and placed into covered aluminum weighing dishes and allowed to thaw prior to weighing.

[3]Mirromatic.

Analytical Methods

Moisture, fat and total nitrogen determinations were made on duplicate samples of cooked and raw, light and dark, meat of fowl by the University of Missouri Experiment Station Chemical Laboratories. The Station Laboratories also analyzed the broth from light and dark meat for total nitrogen.

Moisture. Duplicate 3 to 5 gram samples of ground chicken meat were removed from the aluminum weighing dishes and the weight obtained by difference. The samples were rolled in a strip of cotton which had been weighed and dried previously and placed into glass thimbles which were transferred into tared brass containers. These were dried overnight in a vacuum oven at 65°C and 28 to 30 pounds pressure. Loss in weight was calculated as percent moisture.

Fat. The moisture-free samples, still rolled in cotton, were extracted in a Goldfisch apparatus with anhydrous diethyl ether for 5 to 6 hours. Loss in weight was calculated as percent fat.

Nitrogen. Total nitrogen was determined on meat and broth by the Kjeldahl method as described by The Association of Official Agricultural Chemists (1955). The factor 6.25 was used to convert grams of nitrogen into grams of protein.

Thiamine and riboflavin. Meat samples were assayed for thiamine and riboflavin in duplicate by fluorometric procedures as outlined by The Association of Vitamin Chemists, Inc. (1951). The determination of thiamine included use of polidase S as the enzyme and purification by adsorption and elution of the thiamine on a decalso column. Fluorescence was read on a Farrand photoelectric fluorometer.

Microbiological assays. The chicken meat and broth were assayed for lysine and methionine microbiologically with *Leuconostoc mesenteroides* P-60 as test microorganism. Samples were hydrolyzed for 8 hours at 121°C in 4 N hydrochloric acid. After autoclaving, they were adjusted to pH 6.8, diluted to 100 ml and filtered. The filtrates were further diluted for assay as needed. Lysine and methionine were determined by using the basal medium and the micro method of Steele et al. (1949). Lactic acid produced by the bacteria was titrated against 0.02 N sodium hydroxide with brom thymol blue as the indicator.

A recovery mixture, consisting of the ten essential amino acids, in the same ratio as occurring in casein, was added periodically to samples of meat and broth, prior to hydrolysis, to determine the recovery of lysine and methionine. From this mixture, recovery of lysine in the presence of chicken meat averaged 100%; recovery of methionine averaged 98%.

Preliminary work indicated that amino acids were present in broth in the free form and in the bound form, as polypeptides. Recovery of added lysine from the recovery mixture in the presence of chicken broth averaged 90%, and of added methionine, 93%. It is possible that a shorter period of hydrolysis than the 8-hour period used for broth might have yielded better recoveries.

RESULTS AND DISCUSSION

Yield of Cooked Fowl

The whole ready-to-cook carcasses ranged in weight from 3 pounds to 3 pounds 13 ounces (3.8 pounds) Weights of the ready-to-cook left halves ranged from 744 gm to 1016 gm (1.6 to 2.2 pounds). These amounted to an average of 57% of the weight of the whole ready-to-cook birds. When the left half was again halved to separate light and dark meats, prior to cooking, the upper portions containing light meat averaged 47% and the lower portions containing dark meat averaged 53% of the weight of the uncooked left halves of fowl.

Data representing the percentage yield of lean meat, fat, skin, and the aggregate of these with and without bone are presented in Table 1. All calculations were based on the ready-to-cook weights of the upper and lower portions of the left halves of fowl. There was an average of 40% more fat and 14% less lean meat obtained from the lower portion consisting of dark meat than there was from the upper portion or light meat of cooked fowl.

The yield of meat, fat and skin from cooked light meat averaged 53% and from dark meat, 43% of the ready-to-cook weights. Dawson *et al.* (1960) reported an average yield of 52% for 24 hens which had been cut in half and stewed for 3 hours.

Moisture Content

Light meat. Moisture content of the raw light meat from birds within each group receiving the first three treatments, i.e., air-chill 3 hours, ice water 3 hours and air chill 18 hours, varied by less than 1%. The three birds which had been chilled in ice water for 18 hours differed among themselves by 3%. Mean moisture content of the birds air-chilled in ice water 18 hours was the highest, 72.94%. This is a difference of 1%.

When light meat was cooked the birds which had been air-chilled 3 hours had the largest variation in moisture content. They differed among themselves by 4%. Carcasses receiving the other three treatments showed a variation among samples within each group of 2%. Birds air-chilled for 3 hours had the lowest moisture content, those chilled in ice water 18 hours, the highest. But the difference was less than 1%.

Dark meat. The uncooked dark meat of birds chilled in ice water 18 hours had the highest moisture content, 73.96%. This was only 2% greater than that of carcasses chilled in ice water for 3 hours which had the lowest moisture content (72.21%). The latter value could be attributed to the unusually high fat composition of one sample.

The dark meat of cooked fowl which had been air-chilled for 18 hours yielded meat with 2% more moisture than the driest cooked dark meat which resulted from birds that had been chilled in ice water for 18 hours.

In summary, it was observed that any differences in moisture content between air-chilled and ice water chilled birds were so small as to be negligible.

TABLE 1-PERCENTAGE YIELD FROM LEFT HALVES OF COOKED FOWL, BASED ON READY-TO-COOK WEIGHTS

Portion of fowl	Number	Ready-to cook wt. gm	Total cooked fowl[4] %	Fat %	Skin %	Lean meat %	Total meat, fat, skin %
Light Meat							
Mean	12	393	64	9	9	35	53
Range	12	(354-460)	(61-72)	(7-11)	(8-13)	(30-40)	(45-64)
Dark Meat							
Mean	12	450	58	15	7	21	43
Range	12	(392-550)	(53-61)	(11-18)	(5-7)	(16-24)	(32-49)

[4]Includes bones, skin and lean meat.

TABLE 2-MEAN MOISTURE, FAT, TOTAL NITROGEN AND PROTEIN CONTENT OF FOWL[5]

Chilling medium	Moisture		Fat		Total nitrogen		Protein[6]
	Raw	Cooked	Raw	Cooked	Raw	Cooked	Cooked
	%	%	%	%	%	%	%
			Light Meat				
Air, 3 hrs.	72.05	58.97	1.74	5.21	4.03	5.64	35.3
Ice Water, 3 hrs.	72.53	59.14	2.18	4.61	3.88	5.47	34.2
Air, 18 hrs.	72.59	59.12	1.68	4.18	3.94	5.78	36.2
Ice Water, 18 hrs.	72.94	59.38	2.09	4.16	3.90	5.71	35.7
Overall mean[7]	72.53	59.15	1.92	4.54	3.94	5.65	35.3
			Dark Meat				
Air, 3 hrs.	72.73	56.60	4.02	7.07	3.47	5.70	35.6
Ice Water, 3 hrs.	72.21	57.09	5.36	7.72	3.40	5.26	32.9
Air, 18 hrs.	73.47	57.28	4.05	6.77	3.46	5.60	35.0
Ice Water, 18 hrs.	73.96	55.96	3.73	7.78	3.42	5.56	34.8
Overall mean[7]	73.10	56.73	4.29	7.34	3.44	5.53	34.6

[5]Each figure represents mean of 3 birds.
[6]N X 6.25
[7]Each figure represents mean of 12 birds.

In each instance, variation between groups of birds exhibiting the highest and lowest moisture content was the same or smaller than individual differences among birds receiving the same treatment. Cooked light meat had a slightly higher moisture content than the dark meat.

Fat Content

Light and dark meat. Both light and dark meats varied considerably in fat content. Values for raw light meat ranged from 1.10 to 3.58 gm %; for raw dark meat, from 2.97 to 6.26 gm %. Cooked light meat contained approximately 2½ times as much fat as the raw meat. In this study as in others (Morgan *et al.,* 1949, and Erdsiek *et al.,* 1951), the dark meat was found to be higher in fat content than the light meat.

Total Nitrogen and Protein Content

All samples were analyzed for total nitrogen content so that it could serve as a basis for amino acid data. Light meat had a slightly higher nitrogen content than the dark meat (3.94% vs. 3.44%). This was because the dark meat had more fat than the light meat. Swanson (1953) reported higher nitrogen values for breast muscle than for leg muscle in poultry. Beach, Monks, and Robinson (1943) made the same observation.

Since it is more usual to think of the nutritive value of foods in terms of protein content than in terms of total nitrogen, values for protein were calculated using the factor 6.25. Cooked fowl from which skin, bone, and all visible fat were removed contained approximately 35% protein.

Vitamin Content of Fowl

Thiamine and riboflavin data for raw and cooked, light and dark, meat of fowl and vitamin retention on cooking are summarized in Tables 3 and 4. Data are presented on a wet basis to permit comparisons with values cited in food composition tables. Comparisons as to the effect of chilling medium used in processing and percent retention after cooking are based on vitamin content in the dry, fat-free, meat. Neither chilling medium nor duration of chilling had any effect on thiamine and riboflavin content of fowl in this investigation. Retention of the two vitamins after cooking was not influenced by chilling medium or length of chilling time. Differences between means were tested by the t-test (Snedecor, 1956).

Thiamine. The mean value for thiamine, given on a wet basis, was 0.14 mg/100 gm of raw light meat and 0.16 mg/100 gm of raw dark meat of fowl. This value for light meat is twice that reported by Erdsiek *et al.* (1951), while the value for dark meat is in close agreement with their value of 0.15 mg/100 gm meat. Millares and Fellers (1949) reported 0.097 mg/100 gm of uncooked light meat and 0.176 mg/100 gm uncooked dark meat of fowl. In a more recent study Prudent (1959) reported the thiamine level in fresh, uncooked, 23-week-old cockerels to be 5.588 mcg per gram of dry tissue. This value agreed well with that of the

present investigation which, adjusted to the dry basis, would be 5 mcg per gram. In all of these instances, the fluorometric procedure had been used as the method of assay.

The mean value for thiamine of cooked light meat in this study was 0.22 mg/100 gm of dry, fat-free-tissue. Erdsiek *et al.* (1951) reported 0.14 mg/100 gm of stewed light meat. Their value of 0.52 mg/100 gm for stewed dark meat was considerably higher than the mean obtained in this investigation (0.36 mg/100 gm). Erdsiek stewed 11-week-old cockerels in a pressure cooker saucepan with 2 tablespoons of distilled water for 10 minutes at 15 pounds pressure. The shorter cooking period along with the smaller volume of water would cause one to expect a smaller loss of the nutrient than in the present investigation. Prudent (1959) reported 3.268 mcg/gm of dry tissue for samples of leg muscle of fresh birds roasted to an internal temperature of 190°F. This value is considerably lower than 8 mcg/gm dry tissue which was calculated for pressure-cooked dark meat of the present investigation. For canned chicken meat, Millares and Fellers (1949) reported values of 0.032 and 0.044 mg/100 gm light meat (wet basis) and 0.041 gm/100 gm of dark meat. These values were considerably lower than corresponding values in this study: 0.08 mg/100 gm light meat and 0.13 mg/100 gm dark meat.

Retention of thiamine in the present investigation ranged from 31 to 50% in light meat and 36-68% in dark meat. Erdsiek *et al.* (1951) reported 47% and

TABLE 3-THIAMINE VALUES FOR RAW AND COOKED FOWL AND ITS RETENTION ON COOKING

Chilling medium	Thiamine content[8]				
	Wet basis		Dry, fat-free basis		
	Raw	Cooked	Raw	Cooked	Retention
	mg/100 gm		mg/100 gm		%
			Light Meat		
Air, 3 hrs.	0.13	0.08	0.48	0.21	44
Ice water, 3 hrs.	0.15	0.07	0.58	0.19	33
Air, 18 hrs.	0.15	0.08	0.58	0.22	38
Ice water, 18 hrs.	0.15	0.09	0.62	0.24	39
Overall mean	0.14	0.08	0.57	0.22	38
Overall range	(0.12-0.16)	(0.06-0.09)	(0-45-0.65)	(0.16-0.25)	(31-50)
			Dark Meat		
Air, 3 hrs.	0.15	0.13	0.65	0.36	55
Ice water, 3 hrs.	0.15	0.14	0.67	0.39	58
Air, 18 hrs.	0.17	0.15	0.75	0.41	55
Ice water, 18 hrs.	0.17	0.11	0.75	0.30	40
Overall mean	0.16	0.13	0.70	0.36	52
Overall range	(0.14-0.19)	(0.09-0.16)	(0.63-0.83)	(0.25-0.44)	(36-68)

[8]Each figure represents mean of 3 birds.

68% for 10 samples each of stewed light and dark meats, respectively. Millares and Fellers (1949) found 33% and 45% retention in canned light meat and 23% retention in the dark meat. Prudent (1959) reported 58.5% retention of thiamine in leg muscle of roasted birds.

Riboflavin. The mean value for riboflavin of uncooked light meat was 0.12 mg/100 gm of wet tissue and 0.31 mg/100 gm of uncooked dark meat. These values were slightly higher than figures quoted by Watt and Merrill (1950): raw breast of fryers 0.09 mg/100 gm and leg of fryers 0.24 mg/100 gm. For uncooked cockerels Erdsiek *et al.* (1951) obtained values of 0.17 mg/100 gm for light meat and 0.24 mg/100 gm for dark meat. These workers observed that the values given above, which were determined fluorometrically, were slightly higher than those obtained by microbiological assay. In the present investigation, it was noted that dark meat had 2½ to 3 times as much riboflavin as the light meat.

Upon cooking, retention of riboflavin was considerably better than was the retention of thiamine. For light meat the average was 86% with a range of 72 to 102%. For dark meat, the mean was 77% and the range, 71 to 86%. Certainly, these values were well within the limits of 60 to 100% which Morgan (1960) cited as retention of riboflavin in cooking and canning of poultry, regardless of the method of cooking.

TABLE 4-RIBOFLAVIN VALUES FOR RAW AND COOKED FOWL AND ITS RETENTION ON COOKING

Chilling medium	Riboflavin content[9]				
	Wet basis		Dry, fat-free basis		
	Raw	Cooked	Raw	Cooked	Retention
	mg/100 gm		mg/100 gm		%
			Light Meat		
Air, 3 hrs.	0.13	0.14	0.48	0.39	81
Ice water, 3 hrs.	0.11	0.13	0.42	0.35	83
Air, 18 hrs.	0.12	0.15	0.45	0.40	89
Ice water, 18 hrs.	0.12	0.15	0.47	0.42	89
Overall mean	0.12	0.14	0.46	0.39	86
Overall range	(0.10-0.14)	(0.12-0.16)	(0.39-0.54)	(0.32-0.44)	(72-102)
			Dark Meat		
Air, 3 hrs.	0.32	0.40	1.39	1.10	79
Ice water, 3 hrs.	0.30	0.37	1.35	1.05	78
Air, 18 hrs.	0.31	0.38	1.36	1.07	79
Ice water, 18 hrs.	0.29	0.35	1.33	0.97	73
Overall mean	0.31	0.38	1.36	1.05	77
Overall range	(0.28-0.35)	(0.32-0.42)	(1.23-1.53)	(0.89-1.20)	(71-86)

[9]Each figure represents mean of 3 birds.

Amino Acid Content of Fowl

Lysine and methionine data were presented in Tables 5 and 8. Data were expressed on a weight basis to permit comparisons with values frequently reported in the literature on this basis. To permit comparisons of cooked samples with the raw, amino acid data were based on total nitrogen content.

As much variation in lysine and methionine content was noted among individual birds receiving the same treatment as among groups receiving different treatments. Neither water chilling nor cooking had any appreciable effect on lysine or methionine content in light or dark meat of fowl.

Lysine. Data for lysine content of fowl presented in this study were comparable with values compiled by Orr and Watt (1957) for chicken muscle without skin. In this investigation, the overall mean for light meat was 0.509 gm/gm total nitrogen and for dark meat, 0.556 gm/gm total nitrogen. Orr and Watt gave a minimum value of 0.469 gm/gm total nitrogen and a maximum of 0.622 gm and an average value of 0.549 gm/gm total nitrogen. Evidently these values, which represent 6 samples, pertain to either light or dark meat of chicken.

TABLE 5–LYSINE CONTENT OF RAW AND COOKED, LIGHT AND DARK MEAT OF FOWL[10]

Chilling medium	Lysine content			
	Weight basis		Total nitrogen basis	
	Raw	Cooked	Raw	Cooked
	gm/100 gm		gm/gm	
		Light Meat		
Air, 3 hrs.	2.059	3.087	0.512	0.547
Ice water, 3 hrs.	1.944	3.125	0.501	0.571
Air, 18 hrs.	2.130	3.177	0.526	0.550
Ice water, 18 hrs.	1.964	3.199	0.504	0.560
Overall mean	2.021	3.147	0.509	0.557
Overall range	(1.875–2.247)	(2.909–3.402)	(0.489–0.552)	(0.523–0.605)
		Dark Meat		
Air, 3 hrs.	1.920	3.135	0.553	0.550
Ice water, 3 hrs.	1.875	3.349	0.552	0.637
Air, 18 hrs.	1.914	3.384	0.554	0.604
Ice water, 18 hrs.	1.930	3.424	0.564	0.616
Overall mean	1.910	3.323	0.556	0.602
Overall range	(1.754–2.023)	(3.059–3.596)	(0.507–0.599)	(0.543–0.670)

[10]Each figure represents mean of 3 birds.

In this investigation, there appeared to be a general tendency for dark meat to have a slightly higher content of lysine than the light meat. This was true in both raw and cooked samples. It was noted that in data presented by Millares and Fellers (1948) fresh dark meat of chicken was slightly higher in lysine con-

TABLE 6-LYSINE CONTENT OF LIGHT AND DARK MEAT OF FOWL AND ITS RETENTION ON PROCESSING[11]

Sample and treatment	Lysine content			Lysine content		
	In Sample %	In Protein %	Retention %	In Sample %	In Protein %	Retention %
		Light Meat			Dark Meat	
Raw, air-chilled 3 hrs.	2.06	8.2		1.92	8.8	
Raw, water-chilled 3 hrs.	1.94	8.0	98	1.88	8.8	100
Cooked, air-chilled 3 hrs.	3.09	8.7		3.14	8.8	
Cooked, water-chilled 3 hrs.	3.13	8.9	102	3.35	10.2	116
Raw, air-chilled 18 hrs.	2.13	8.4		1.91	8.9	
Raw, water-chilled 18 hrs.	1.96	8.0	95	1.93	9.0	101
Cooked, air-chilled 18 hrs.	3.18	8.8		3.38	9.7	
Cooked, water-chilled 18 hrs.	3.20	9.0	102	3.42	9.7	100

[11]Values for percent lysine in protein were calculated to 16% nitrogen.

TABLE 7-LYSINE CONTENT OF LIGHT AND DARK MEAT OF FOWL AND ITS RETENTION ON COOKING[12]

Sample and treatment	Lysine content			Lysine content		
	In Sample %	In Protein %	Retention %	In Sample %	In Protein %	Retention %
	Light Meat			Dark Meat		
Raw, air-chilled, 3 hrs.	2.06	8.2		1.92	8.2	
Cooked, air-chilled, 3 hrs.	3.09	8.7	106	3.14	8.7	106
Raw, air-chilled, 18 hrs.	2.13	8.4		1.91	8.9	
Cooked, air-chilled, 18 hrs.	3.18	8.8	105	3.38	9.7	105
Raw, water-chilled, 3 hrs.	1.94	8.0		1.88	8.8	
Cooked, water-chilled, 3 hrs.	3.13	8.9	111	3.35	10.2	116
Raw, water-chilled, 18 hrs.	1.96	8.0		1.93	9.0	
Cooked, water-chilled, 18 hrs.	3.20	9.0	113	3.42	9.7	108

[12]Values for percent lysine in protein were calculated to 16% nitrogen.

tent than was the fresh light meat. Millares and Fellers determined lysine by microbiological assay also. Beach *et al.* (1943) using the chemical method of Kossel-Black found no differences in lysine content of light and dark meat of chicken.

Retention of lysine on processing (Table 6) and cooking (Table 7) was calculated on a protein basis and by considering the air-chilled birds as controls. With light meat, retention on processing ranged from 95 to 102%; in dark meat, from 100 to 116%. Data for cooked birds were included also. On the basis of this comparison, it was evident that chilling fowl in ice water for 3 hours and for 18 hours had no detrimental effect on lysine content.

Lysine was not lost on cooking. Retention in light meat ranged from 105 to 113% with an average of 109%. Retention in dark meat ranged from 100 to 116% for an average retention of 108%. Greenhut and co-workers (1948) found no destruction of lysine during cooking of beef, lamb, pork and veal. Millares and Fellers (1949) reported 108% retention of lysine in cooked light meat of fowl but only 89.5% in cooked dark meat.

Methionine. Data for methionine reported in this investigation were in agreement with those reported elsewhere. For 6 samples of chicken muscle without skin, Orr and Watt (1957) cited a range of 0.134 to 0.195 gm/gm total nitrogen. Millares and Fellers (1948) reported values of 2.14 gm/16 gm N for light meat and 2.77 gm/16 gm N for dark meat of 28 fowl. These values correspond to

TABLE 8-METHIONINE CONTENT OF RAW AND COOKED, LIGHT AND DARK MEAT OF FOWL

Chilling medium	Methionine content			
	Weight basis		Total nitrogen basis	
	Raw	Cooked	Raw	Cooked
	gm/100 gm		gm/gm	
		Light Meat		
Air, 3 hrs.	0.640	0.954	0.159	0.169
Ice water, 3 hrs.	0.635	0.991	0.164	0.181
Air, 18 hrs.	0.701	1.096	0.178	0.190
Ice water, 18 hrs.	0.694	1.035	0.178	0.181
Overall mean	0.667	1.019	0.169	0.180
Overall range	(0.622-0.728)	(0.904-1.147)	(0.157-0.188)	(0.160-0.195)
		Dark Meat		
Air, 3 hrs.	0.606	0.975	0.175	0.171
Ice water, 3 hrs.	0.586	0.959	0.172	0.182
Air, 18 hrs.	0.631	1.038	0.182	0.185
Ice water, 18 hrs.	0.584	1.012	0.171	0.182
Overall mean	0.602	0.996	0.175	0.180
Overall range	(0.532-0.699)	(0.801-1.079)	(0.157-0.201)	(0.149-0.204)

TABLE 9-METHIONINE CONTENT OF LIGHT AND DARK MEAT OF FOWL AND ITS RETENTION ON PROCESSING[13]

Sample and treatment	Methionine content			Methionine content		
	In Sample %	In Protein %	Retention %	In Sample %	In Protein %	Retention %
		Light Meat			Dark Meat	
Raw, air-chilled, 3 hrs.	0.640	2.5		0.606	2.8	
Raw, water-chilled, 3 hrs.	0.635	2.6	104	0.586	2.8	100
Cooked, air-chilled, 3 hrs.	0.954	2.7		0.975	2.7	
Cooked, water-chilled, 3 hrs.	0.991	2.9	107	0.959	2.9	107
Raw, air-chilled, 18 hrs.	0.701	2.8		0.631	2.9	
Raw, water-chilled, 18 hrs.	0.694	2.8	100	0.584	2.7	93
Cooked, air-chilled, 18 hrs.	1.096	3.0		1.038	3.0	
Cooked, water-chilled, 18 hrs.	1.035	2.9	97	1.012	2.9	97

[13]Values for percent methionine in protein were calculated to 16% nitrogen.

TABLE 10-METHIONINE CONTENT OF LIGHT AND DARK MEAT OF FOWL AND ITS RETENTION ON COOKING[14]

Sample and treatment	Methionine content			Methionine content		
	In Sample %	In Protein %	Retention %	In Sample %	In Protein %	Retention %
		Light Meat			Dark Meat	
Raw, air-chilled, 3 hrs.	0.640	2.5		0.606	2.8	
Cooked, air-chilled, 3 hrs.	0.954	2.7	108	0.975	2.7	96
Raw, air-chilled, 18 hrs.	0.701	2.9		0.631	2.9	
Cooked, air-chilled, 18 hrs.	1.096	3.0	103	1.038	3.0	103
Raw, water-chilled, 3 hrs.	0.635	2.6		0.586	2.8	
Cooked, water-chilled, 3 hrs.	0.991	2.9	112	0.959	2.9	104
Raw, water-chilled, 18 hrs.	0.694	2.8		0.584	2.7	
Cooked, water-chilled, 18 hrs.	1.035	2.9	104	1.012	2.9	107

[14] Values for percent methionine in protein were calculated to 16% nitrogen.

TABLE 11-TOTAL NITROGEN, PROTEIN, LYSINE AND METHIONINE CONTENT OF BROTH FROM LIGHT AND DARK MEAT OF FOWL

Chilling medium	Broth volume ml	N in Total volume gm	Protein[15] in total volume gm	Lysine in total mg	Lysine in volume mg/gm N	Methionine in total mg	Methionine in volume mg/gm N
			Light Meat				
Air, 3 hrs.	106	0.66	4.11	67	102	14	21
Ice water, 3 hrs.	130	0.72	4.52	90	125	20	28
Air, 18 hrs.	121	0.68	4.24	84	124	16	24
Ice water, 18 hrs.	110	0.62	3.89	71	115	13	21
Overall mean	117	0.67	4.19	78	116	16	24
			Dark Meat				
Air, 3 hrs.	124	0.56	3.51	80	143	20	36
Ice water, 3 hrs.	146	0.63	3.96	109	173	23	37
Air, 18 hrs.	119	0.49	3.04	83	169	17	35
Ice water, 18 hrs.	118	0.48	3.03	75	156	13	27
Overall mean	127	0.54	3.38	86	159	18	33

[15] N x 6.25

values of 2.70 and 2.80 gm/16 gm N for raw light and dark meats, respectively, in this study. Fry and Stadelman (1960) reported values of 2.97 gm/16 gm N for light meat and 2.90 gm/16 gm N for dark meat of the six 9-week-old birds which they had studied.

It was evident from data presented in Table 9 that the method of processing had no effect on retention of methionine in light or dark meat of fowl. Methionine was not lost on cooking (Table 10). Retention in light meat averaged 107%; in dark meat 102%.

Broth

Broth from light and dark meat was analyzed separately for total nitrogen, lysine and methionine content and findings are presented in Table 11. Broth from light meat varied in volume from 98 to 145 ml; from dark meat, from 100 to 163 ml. The amount of nitrogen in broth was small: in light meat, it varied from 0.60 to 0.74 gm per entire volume of broth; in dark meat, from 0.45 to 0.68 gm. The nitrogen (and protein) content of broth made from light meat was slightly higher than that obtained from dark meat. The concentration of lysine and methionine in broth was very small. No clear-cut relationships of any sort were observed.

SUMMARY AND CONCLUSIONS

A popular method of cooling eviscerated poultry carcasses in commercial use is that of chilling in a tank of air-agitated slush ice. This study was undertaken to learn if there is a loss of the water-soluble vitamins, thiamine and riboflavin, in water-chilled fowl and what effect cooking would have on the retention of thiamine, riboflavin, lysine and methionine in such fowl.

Twelve, 19 month-old fowl weighing between 3 pounds and 3 pounds 13 ounces, eviscerated, were studied. They had been raised and fed under similar conditions. Method of processing up until chilling was the same also. Three birds were air-chilled for 3 hours, 3 were air-chilled 18 hours, 3 were chilled in ice water 3 hours, and 3 were in ice water 18 hours. After chilling, the birds were split in half, placed in Cryovac bags and stored in a freezer.

When they were removed from the freezer, the water-chilled carcasses could be identified readily because of the large amount of ice crystals in the visceral cavity. The carcasses were thawed slowly so that no drip was produced. The left side of each was cut crosswise to separate light and dark meats. Both were cooked simultaneously in separate containers in a large pressure saucepan with 600 ml distilled water, at 10 pounds pressure for 35 minutes. The corresponding right side was analyzed raw.

The yield of meat, fat, and skin from cooked light meat averaged 53% and from dark meat 43% of the ready-to-cook weight. Differences in moisture content between air-chilled and ice-water chilled birds were so small as to be negligible Cooked light meat had a slightly higher moisture content than the dark

meat, but dark meat was higher in fat content. Cooked fowl from which skin, bone and visible fat were removed had approximately 35% protein.

Neither chilling medium nor duration of chilling appeared to have any effect on thiamine and riboflavin content of fowl or on their retention after cooking. Retention of thiamine in cooked light meat averaged 38%, in dark meat, 52%. Retention of riboflavin in cooked light meat averaged 86%, in dark meat 77%.

Neither water-chilling nor cooking had any appreciable effect on lysine or methionine content of the meat. The variation between groups receiving different treatments was the same or less than individual differences among birds receiving the same treatment.

The concentration of nitrogen, lysine and methionine in broth was very small. Broth made from light meat contained slightly more nitrogen than that from dark meat.

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