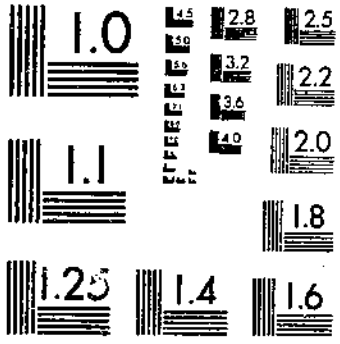
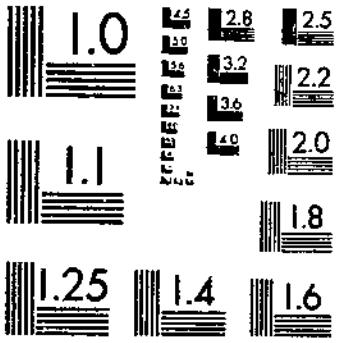
START

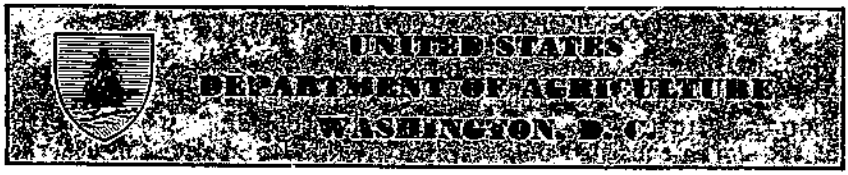


MICROCOPY RESOLUTION TEST CHART
NATIONAL BUREAU OF STANDARDS-1963-A



MICROCOPY RESOLUTION TEST CHART
NATIONAL BUREAU OF STANDARDS-1963-A

Technical Bulletin No. 768 . April 1941



Quality of Frozen Poultry as Affected by Storage and Other Conditions[1]

By HAROLD M. HARSHAW, *assistant biochemist, Animal Nutrition Division Bureau of Animal Industry;* WALTER S. HALE, *chemist,* and T. L. SWENSON, formerly *chemist, Food Research Division,*[2] *Bureau of Agricultural Chemistry and Engineering;* LUCY M. ALEXANDER, *associate home economics specialist, Foods and Nutrition Division, Bureau of Home Economics;* and R. R. SLOCUM, *senior marketing specialist, Division of Dairy and Poultry Products, Agricultural Marketing Service*

United States Department of Agriculture, Bureaus of Animal Industry, Agricultural Chemistry and Engineering, and Home Economics and the Agricultural Marketing Service, in cooperation with the Institute of American Poultry Industries

CONTENTS

INTRODUCTION

Since about 1925 certain changes have been taking place in commercial practices in the preparation and storage of dressed poultry. Formerly frozen poultry were rather generally stored at temperatures of about 10° F. At present, however, temperatures of 0° or lower are common. Another practice that has come into much more general use is that of drawing chickens before freezing and storage. The use of such procedures has made it desirable to investigate their effect on the quality of poultry meat.

The quality of poultry meat may be affected by storage in a number of ways. The carcass may deteriorate externally through the drying out of the skin, a loss of its natural soft glossy appearance, and the development of freezer burn. The flesh may undergo chemical changes, especially in the loss of moisture and the hydrolysis or oxidation of the fat and protein. These changes may affect the desirability and palatability of the meat after it is cooked. To study such effects as influenced by storage temperatures and drawing, the experiment reported in this bulletin was made.

[1] Received for publication June 27, 1940.

[2] Dr. Hale is now a chemist in the Enzyme Research Laboratory; Dr. Swenson is director of the Western Regional Research Laboratory.

EXPERIMENTAL PROCEDURE

Cockerels only were used in the experiment and were obtained from two Iowa farm flocks. These flocks were selected because the birds comprising them were relatively uniform in breeding and type. One of the flocks consisted of Barred Plymouth Rocks and the other of Buff Orpingtons. The chicks of each breed were hatched in the spring from eggs obtained from only one breeding flock and were reared on free range, with a supplement of mash and grain.

In the fall, the birds from both flocks were fattened together for 5 days under the same conditions in a commercial feeding station. They were fed a proprietary mixed feed to which condensed buttermilk and water were added. The birds were killed on the sixth day after the usual 12-hour period without feed and were then picked after being slack-scalded. They were held overnight at a temperature of 33° F. The next day some of the birds were drawn, and all were packed in wooden boxes to be frozen at −5° to −6°. After being frozen, they were shipped from Omaha to a storage warehouse in Chicago by refrigerated truck. Approximately 24 hours was required for this shipment. Some of the boxes were stored at 0° and the others at −20° under the usual conditions of freezing in refrigerators. A comparison was not made with birds held after they had been frozen under the methods of quick freezing. Placement in storage occurred on November 14, 1933.

In this manner, 150 individuals of each breed were prepared so that boxes containing 6 birds of each breed could be held in storage as follows:

Light birds, drawn and stored at −20° F.
Heavy birds, drawn and stored at −20° F.
Light birds, undrawn and stored at −20° F.
Heavy birds, undrawn and stored at −20° F.
Light birds, undrawn and stored at 0° F.
Heavy birds, undrawn and stored at 0° F.

The separation between light and heavy birds was made at the weight of 5 pounds and 8 ounces, all birds over that weight being classed as heavy.

Representative boxes of birds were removed from storage for examination on November 26, 1934, November 21, 1935, and December 2, 1936. After withdrawal from storage, the boxes were shipped by express in a frozen condition to Washington, D. C., for the purpose of examination and testing the birds in the laboratories of the cooperating administrative units of the United States Department of Agriculture.

The boxes were opened, and the individual birds were graded on their external appearance by specialists of the Bureau of Animal Industry and the Agricultural Marketing Service. Representative birds were then tested as to their quality by specialists of the Bureau of Agricultural Chemistry and Engineering and the Bureau of Home Economics.

LOSSES IN WEIGHT AND EXTERNAL APPEARANCE DURING STORAGE

The percentages of loss in weight during the storage periods were calculated for the different boxes of poultry and are presented in table 1. There was some variation in this respect in the different

lots of birds. The relative loss in weight was consistently greater in the birds stored at 0° F. than in those stored at −20°, being more than twice as high on the average. The loss at the higher temperature did not increase appreciably at the end of 2 years but was considerably greater after 3 years of storage. There was also an indication that the 3-year loss at −20° was greater than the 1- or 2-year loss, but the results for this temperature hold only for the heavy birds. The drawn birds lost a greater percentage of weight, in every case, than the undrawn birds stored at the same temperature, but the differences were often slight. The other conditions of the experiment did not appear to affect the losses in weight during storage, although no data were obtained in regard to the influence of breed in this respect.

TABLE 1.—*Effect of drawing and temperature of storage on loss of weight of birds stored 1, 2, and 3 years*

Dressed condition	Storage temperature	Weight group	Loss in weight at end of—		
			First year	Second year	Third year
	° F.		*Percent*	*Percent*	*Percent*
Drawn	−20	Light	1.20	1.16	1.19
		Heavy	.98	.95	1.96
Undrawn	−20	Light	1.00	.00	.53
		Heavy	.79	.79	1.13
	0	Light	1.96	2.04	3.57
		Heavy	2.34	2.35	3.91

All the carcasses were rated for color, bloom, condition of skin, and freezer burn, according to the method shown in table 2, which represents the consensus of opinion of a number of individuals experienced in the grading of storage poultry. It was designed to provide a simple, easily applied measure of the deterioration which might be expected to occur in the appearance of dressed poultry during storage. It does not include any of the quality factors due to the fleshing and conformation of the individual bird.

As shown in table 2, for each of the characteristics there are five possible ratings, which are given the numerical values of 1 to 5. By the use of these values, a numerical rating for each bird and each classification of birds in regard to the desirability of external appearance may be obtained. Total ratings for six birds in each breed after each year of storage are given in table 3.

TABLE 2.—*Basis of rating numerically the external appearance of storage poultry for quality factors*

Quality factor	Rating No.				
	1	2	3	4	5
Color (bleached or darkened)	Very marked change.	Marked change.	Medium change.	Slight change	Natural.
Bloom	None	Poor	Fair	Good	Excellent.
Condition of skin	Very dry	Dry	Slightly dry	Slightly glossy	Soft glossy.
Freezer burn	Pronounced	Medium	Slight	Very slight	None.

TABLE 3.—*Total rating for external appearance of 6 birds in each breed after 1, 2, and 3 years of storage at −20° and 0° F.*[1]

1 YEAR

Dressed condition	Storage temperature	Weight group	Breed	Rating for—				
				Color	Bloom	Condition of skin	Freezer burn	Total
	°F.							
Drawn	−20	Light	Barred Plymouth Rock	30	21	21	23	95
			Orpington	30	22	22	29	103
		Heavy	Barred Plymouth Rock	30	21	18	23	92
			Orpington	30	19	19	25	93
Undrawn	−20	Light	Barred Plymouth Rock	20	23	23	30	105
			Orpington	30	24	24	30	108
		Heavy	Barred Plymouth Rock	20	20	20	21	91
			Orpington	30	20	20	26	96
	0	Light	Barred Plymouth Rock	30	19	19	13	81
			Orpington	30	22	22	14	88
		Heavy	Barred Plymouth Rock	11	11	18	8	48
			Orpington	30	20	18	12	80

2 YEARS

Drawn	−20	Light	Barred Plymouth Rock	30	17	18	20	85
			Orpington	30	17	18	22	87
		Heavy	Barred Plymouth Rock	30	19	18	21	88
			Orpington	30	18	18	23	89
Undrawn	−20	Light	Barred Plymouth Rock	30	18	18	23	89
			Orpington	30	18	18	21	87
		Heavy	Barred Plymouth Rock	30	18	18	22	88
			Orpington	30	18	18	21	87
	0	Light	Barred Plymouth Rock	30	10	14	13	67
			Orpington	30	17	13	16	76
		Heavy	Barred Plymouth Rock	30	10	18	10	68
			Orpington	30	10	18	7	65

3 YEARS

Drawn	−20	Light	Barred Plymouth Rock	20.0	12.0	13.5	15.0	60.5
			Orpington	20.0	12.5	12.0	13.0	57.5
		Heavy	Barred Plymouth Rock	20.0	15.5	17.5	16.5	69.5
			Orpington	17.0	16.0	16.0	16.5	65.5
Undrawn	−20	Light	Barred Plymouth Rock	18.0	13.0	12.0	12.0	55.0
			Orpington	20.0	13.0	12.0	12.0	57.0
		Heavy	Barred Plymouth Rock	21.0	14.5	13.0	14.0	62.5
			Orpington	21.0	16.0	14.0	15.0	66.0
	0	Light	Barred Plymouth Rock	8.5	6.5	9.5	6.5	29.0
			Orpington	8.0	7.5	9.0	6.5	29.0
		Heavy	Barred Plymouth Rock	7.0	7.5	9.0	6.0	29.5
			Orpington	8.0	6.0	7.5	6.0	27.5

[1] Method of obtaining data in this and subsequent similar tables is shown in table 2.

Table 3 shows certain consistent differences and trends from year to year. However, the rating for one group—the heavy, undrawn Barred Plymouth Rocks stored for 1 year at 0° F.—was unusually low as compared with the Buff Orpingtons of the same classification. The carcasses in the former group had rather poor color and bloom, the cause of which could not be ascertained. The Barred Plymouth Rocks of this classification, stored for 2 and 3 years, had practically the same score as the corresponding Buff Orpingtons. With this exception, the scores of the different groups of birds decreased with each year of storage. At the higher temperature, 0°, there was a greater deterioration in external appearance than at −20°, and this difference was more marked at the end of 3 years of storage than it was after 1 or 2 years.

There was no consistent difference in score between the two breeds or between the drawn and undrawn birds. The smaller birds rated slightly better at the end of the first year, but there was no essential difference between the two sizes of birds thereafter.

With the exception already noted, color of the birds was normal after 1 and 2 years of storage, but there was a noticeable deterioration in color during the third year. The scores for bloom and condition of skin were slightly less after 2 years of storage than after 1 year, and much less after 3 years of storage. The extent of the development of freezer burn became more marked each year, this effect being greatest during the third year. The greatest freezer burn occurred on the outside birds on the side next to the box. There was also more freezer burn on the backs of the birds. These effects were all accentuated at the higher storage temperature. The average numerical ratings for these characteristics in the birds stored for 3 years at 0° F. were about one-half that of the birds stored at −20°. This difference was not so great after 1 and 2 years of storage.

The results indicate that there is a continued deterioration in the external appearance of dressed poultry with an increase in the length of storage as shown by color, bloom, condition of skin, and degree of freezer burn. This effect is greater at a storage temperature of 0° F. than at −20°. Breed, size, and drawing did not show any influence in this respect.

CHEMICAL CHANGES

In 1934, after 1 year of storage, and in 1936, after 3 years of storage, chemical determinations were made on the tissues of representative chickens to investigate the changes that had taken place. For comparison with these results, determinations were made on fresh-frozen chickens in 1933, 1934, and 1936. The chemical examination comprised the following: Moisture in breast muscle and skin; acidity of intraperitoneal fat; glucose in breast muscle; acidity, glutathione, amino nitrogen, and proteinase activity of the aqueous extract of the combined leg and breast muscle; proteinase activity of the glycerin extract of leg muscle.

Many chemical changes are known to occur in meat during storage, but the ordinary analytical determinations detect spoilage only after it has been evident to the senses for a long time. The aim of the present studies was to find some measurable difference between fresh and stored poultry as a criterion of successful preservation.

Beside determinations of amino nitrogen in muscle extracts and the acidity of fat and of muscle extracts, which are all more or less usual procedures in following the course of autolytic processes, an attempt was made to learn whether the enzyme system of protein break-down had undergone any change in activity. Water and glycerin extracts of the muscles were tested for their capacity to break down gelatin. No definite results were obtained. A test of the sulfhydryl groups in muscle extracts by Tunnicliffe's method [3] also gave no definite results.

The percentages of moisture in the breast muscle and skin were determined as directed by the Association of Official Agricultural

[3] TUNNICLIFFE, H. E. GLUTATHIONE. THE OCCURRENCE AND QUANTITATIVE ESTIMATION OF GLUTATHIONE IN TISSUES. Biochem. Jour. 19: 194–198. 1925.

Chemists.[4] The moisture content of the breast muscle ranged from 59.7 to 76.4 percent and averaged 71.2 percent; that of the skin varied from 30.0 to 57.5 and averaged 42.8 percent. The results did not indicate any change in the moisture content of breast muscle or skin due to any of the conditions studied. There was a greater variation in this respect between the individual birds than between any of the groups of birds.

The acidity of the fat was determined by titration of the ether extract of fatty tissue with sodium alcoholate according to the method of the Association of Official Agricultural Chemists [5] for the acidity of fat in egg yolk. Samples of abdominal adipose tissue were used for this purpose. The acidity of fat, expressed as the volume of 0.05*N* sodium ethylate required to neutralize 1 gm. of fat extract, varied from 0.3 to 1.5 cc. and averaged 0.7 cc. There was an indication in the results obtained that the acidity of the fat increased during storage. The average volume recorded in the titration of the fat samples was 0.5 cc. in the fresh-frozen birds and 0.8 cc. in the stored birds. However, there was more variation in the results obtained between the individual birds than between the groups of birds; consequently, no definite conclusions could be drawn.

The quantity of reducing sugars in the breast muscle was determined. Five grams of the muscle tissue was thoroughly ground in a mortar with sand and a little water, and the volume of the extract was brought to 35 cc. by the addition of water. The rest of the procedure was according to Benedict's modification of the method of Folin and Wu for blood sugar,[6] except that sodium tungstate and sulfuric acid were added while the mixture was stirred in the mortar. The values obtained from these determinations ranged from 44 to 355 mg. per 100 gm. of breast muscle and averaged 196 mg. The data indicate that the reducing sugars increased in breast muscle during storage, the average values being 151 mg. in the fresh-frozen birds and 208 mg. in the stored birds. However, the variation between individual birds was too great for the averages to be significant.

Determinations were made on the aqueous extract of muscle tissue to study the changes taking place in the proteins. The extracts were prepared by grinding 25 gm. of muscle (half from the breast and half from the leg) with sand and a little water and then diluting to 250 cc. with water. The suspension was filtered through cheesecloth and then through filter paper on which a layer of filtercel had been deposited. The filtrate was kept cool, and 10-cc. portions were used for the following determinations: (1) Titration with 0.1*N* alcoholic potassium hydroxide in hot alcohol, with thymolphthalein as an indicator, the method being that of Willstätter and Waldschmidt-Leitz[7] for protein fragments; (2) titration with 0.01 N iodine with sodium nitroprusside as an outside indicator to determine the sulfhydryl groups, this method being proposed by Tunnicliffe;[8] (3) estimation of amino nitrogen in the Van Slyke apparatus.[9]

[4] ASSOCIATION OF OFFICIAL AGRICULTURAL CHEMISTS. OFFICIAL AND TENTATIVE METHODS OF ANALYSIS . . . Compiled by the committee on editing methods of analysis. Ed. 4, 710 pp., illus. Washington, D. C. 1935. See p. 335.

[5] See p. 303 of reference cited in footnote 4.

[6] BENEDICT, STANLEY R. THE ESTIMATION OF SUGAR IN BLOOD AND NORMAL URINE. Jour. Biol. Chem. 68: 759-767. 1926.

[7] WILLSTÄTTER, RICHARD, WALDSCHMIDT-LEITZ, ERNST, DUSAITURRIA, SALUSTIANO, and KÜNSTNER, GERHARD. ZUR KENNTNIS DES TRYPSINS. XV. ABHANDLUNG ÜBER PANKREAS-ENZYME. Ztschr. f. Physiol. Chem. 161: [191]-203, illus. 1926.

[8] TUNNICLIFFE, H. E. See footnote 4.

[9] VAN SLYKE, DONALD D. THE QUANTITATIVE DETERMINATION OF ALIPHATIC AMINO GROUPS. II. Jour. Biol. Chem. 12: 275-284, illus. 1912.

The results obtained from these three determinations showed more variation between individual birds than between the groups of birds. There were no indications that drawing, length of storage, or temperature of storage had any effect. The volume of 0.1N potassium hydroxide required to neutralize the extract from 1 gm. of muscle tissue varied from 0.95 to 1.40 cc. and averaged 1.25 cc. The 0.01N iodine solution used in titrating the extract from 1 gm. of muscle ranged from 0.24 to 0.70 cc. and averaged 0.38 cc. The volume of amino nitrogen per gram of muscle varied from 1.05 to 1.62 cc. and the average was 1.24 cc.

In view of the inconclusive results, the detailed data are omitted.

BACTERIOLOGICAL STUDIES

The bacteriological studies involved the determination of the number of organisms per gram of muscle tissue and the presence or absence of anaerobic organisms. For the former study, samples of tissue from the breast muscle and inner thigh muscle were ground aseptically with sand, use being made of nine volumes of physiological salt solution for dilution. Further dilutions were made from this extract. Nutrient agar was used as a culture media and the cultures were incubated for 48 hours at 37.5° C. The presence of anaerobic organisms was detected by inoculation of deep paraffin-sealed meat tubes.

There was a wide variation in the number of bacteria per gram of muscle, the counts ranging from about 1,000 to 40,000. There was no indication that these counts were affected by any of the conditions of the experiment. Anaerobes were found to be present in 21 of 24 samples from fresh-frozen chickens and in 20 of 38 samples from stored birds. The anaerobic organisms were found in samples of leg muscle from 16 of 19 stored birds, but in only 4 of 19 samples of the breast muscle of such birds.

COOKED-MEAT STUDIES

In 1934, after the chickens had been in storage for 1 year, 3 Barred Plymouth Rocks and 3 Buff Orpingtons from each of the 6 lots were cooked to determine the shrinkage during cooking, the time required for cooking, and the palatability of the meat after cooking. The 2 breeds were cooked on alternate days, 1 chicken from each of the 6 storage lots on 1 day. In addition to the stored chickens, fresh-frozen and fresh-killed chickens were cooked for comparison. Two fresh-frozen birds, 1 light and 1 heavy, were cooked each day that a stored chicken was cooked. Following the tests on 48 frozen chickens, an extra day was given to the cooking and testing of 8 fresh-chilled chickens from a Washington, D. C., market. These birds were selected by a Department poultry specialist and were cockerels of good market quality, as judged by appearance.

In each of the last 2 years—1935 and 1936—three Barred Plymouth Rocks and three Buff Orpingtons from each of the six storage lots were cooked by the method used in the 1934 tests. One fresh-frozen and one fresh-chilled chicken were included on each day of cooking the stored chickens. The fresh-chilled chickens were supplied from the United States Department of Agriculture Beltsville Research Center, Beltsville, Md.

The fresh-frozen chickens were fattened under the same conditions as the stored birds and were killed and frozen approximately 2 weeks before cooking.

All chickens were weighed when ready for the pan, stuffed with fine dry bread crumbs, trussed, and dusted lightly with flour. No seasoning was used. Each stuffed chicken was weighed, then placed breast down on a rack in an open roasting pan, with no water added, and put into a moderate gas oven, at 165° C. (329° F.). For even cooking, chickens were turned every 15 minutes, following the order from breast to side, to back, to other side, to breast again. The chickens were cooked at 165° C. until the wing joints had softened and the thigh meat was tender when pierced with a skewer. They were then removed from the oven, weighed again, and were ready to carve and serve to the judges.

Shrinkage and Cooking Time

The shrinkage, or loss of weight during roasting, was determined for each chicken by subtracting the weight after cooking from the weight of the stuffed bird before cooking. The losses consist in the loss in drippings, which is the weight of the mixture of fat and juice that cooks out of the chicken and collects in the roasting pan, and the evaporation loss, which is the difference between total loss and drippings loss. The total shrinkage and the two fractions were calculated for each chicken as the percentage of the weight of the stuffed chicken before being cooked. In 1934 the weight of the stuffing averaged 8.0 percent of the weight of light chickens and 7.5 percent of that of heavy chickens; in 1935, 8.1 and 6.6 percent, respectively; and in 1936, 8.8 and 7.6 percent, respectively.

The time required in cooking was calculated as the number of minutes per pound of the stuffed chicken.

The experimental data on shrinkage and cooking time for the 3 years are presented in table 4.

Table 4.—*Shrinkage and cooking time of chickens after 1, 2, and 3 years of storage at −20° and 0° F., and of fresh-frozen and fresh-chilled controls*

1-YEAR STORAGE

Dressed condition	Storage temperature	Weight group	Breed of chicken	Chickens	Average weight of stuffed, uncooked chicken	Shrinkage during roasting: Evaporation	Shrinkage during roasting: Drippings	Shrinkage during roasting: Total	Cooking time per pound
	°F.			Number	Grams	Percent	Percent	Percent	Minutes
Drawn	−20	Light	Barred Plymouth Rock	3	1,444	12.3	2.1	14.4	32.6
			Buff Orpington	3	1,303	13.5	1.7	15.2	36.8
		Heavy	Barred Plymouth Rock	3	1,839	14.7	1.6	16.3	34.3
			Buff Orpington	3	1,949	13.7	2.7	16.4	28.6
Undrawn	−20	Light	Barred Plymouth Rock	3	1,429	13.5	1.4	14.9	37.4
			Buff Orpington	3	1,411	13.0	2.1	15.1	36.5
		Heavy	Barred Plymouth Rock	3	1,963	14.2	2.8	17.0	32.0
			Buff Orpington	3	2,000	12.1	3.4	15.5	29.2
	0	Light	Barred Plymouth Rock	3	1,373	13.1	2.1	15.2	36.8
			Buff Orpington	3	1,622	14.8	2.3	17.1	35.6
		Heavy	Barred Plymouth Rock	3	1,759	14.7	2.7	17.4	31.7
			Buff Orpington	3	1,984	13.3	3.8	17.1	26.0
Fresh frozen[1]		Light	Barred Plymouth Rock	3	1,351	13.2	.8	14.0	38.1
			Buff Orpington	3	1,422	11.3	1.9	13.2	34.1
		Heavy	Barred Plymouth Rock	3	1,580	12.4	1.9	14.3	32.9
			Buff Orpington	3	1,629	14.4	1.6	16.0	32.1
Fresh chilled[1]		Light	(2)	4	1,393	14.4	3.8	18.2	42.5
		Heavy	(2)	4	1,737	16.7	3.7	20.4	34.6

[1] Not stored; controls.

[2] Not known.

TABLE 4.—*Shrinkage and cooking time of chickens after 1, 2, and 3 years of storage at −20° and 0° F., and of fresh-frozen and fresh-chilled controls*—Continued

2-YEAR STORAGE

Dressed condition	Storage temperature	Weight group	Breed of chicken	Chickens	Average weight of stuffed, uncooked chicken	Shrinkage during roasting: Evaporation	Shrinkage during roasting: Drippings	Shrinkage during roasting: Total	Cooking time per pound
	°F.			*Number*	*Grams*	*Percent*	*Percent*	*Percent*	*Minutes*
Drawn	−20	Light	Barred Plymouth Rock	3	1,406	14.5	3.4	17.9	37.5
			Buff Orpington	3	1,589	15.6	3.5	19.1	38.1
		Heavy	Barred Plymouth Rock	3	1,754	19.0	2.6	21.6	40.0
			Buff Orpington	3	1,962	16.8	3.7	20.5	33.6
Undrawn	−20	Light	Barred Plymouth Rock	3	1,261	14.7	2.4	17.1	39.6
			Buff Orpington	3	1,426	14.3	3.0	17.3	36.1
		Heavy	Barred Plymouth Rock	3	1,693	20.1	3.2	23.3	38.3
			Buff Orpington	3	1,852	18.4	3.8	22.2	36.7
	0	Light	Barred Plymouth Rock	3	1,388	16.2	3.7	19.9	41.4
			Buff Orpington	3	1,334	16.7	3.0	19.7	40.0
		Heavy	Barred Plymouth Rock	3	1,624	13.7	3.0	16.7	35.0
			Buff Orpington	3	1,859	17.4	3.3	20.7	38.1
Fresh frozen [1]		Heavy	Barred Plymouth Rock	3	1,784	16.5	4.6	21.1	37.2
			Buff Orpington	3	1,700	16.9	3.3	20.2	36.0
Fresh chilled [1]		do	Barred Plymouth Rock	3	2,268	15.2	5.4	20.6	30.5
			Buff Orpington	3	2,392	15.9	5.0	20.9	30.4

3-YEAR STORAGE

Drawn	−20	Light	Barred Plymouth Rock	3	1,400	14.1	2.9	17.0	38.8
			Buff Orpington	3	1,489	14.4	3.0	17.4	38.6
		Heavy	Barred Plymouth Rock	3	1,502	16.0	3.2	19.2	34.4
			Buff Orpington	3	1,741	13.1	2.6	15.7	38.4
Undrawn	−20	Light	Barred Plymouth Rock	3	1,352	14.5	3.1	17.6	37.6
			Buff Orpington	3	1,426	14.5	3.0	17.5	39.8
		Heavy	Barred Plymouth Rock	3	1,920	17.0	3.5	20.5	32.6
			Buff Orpington	3	1,980	14.4	4.3	18.7	32.7
	0	Light	Barred Plymouth Rock	3	1,342	12.2	3.2	15.4	37.4
			Buff Orpington	3	1,375	14.5	3.2	17.7	38.3
		Heavy	Barred Plymouth Rock	3	1,812	14.3	3.4	17.7	31.2
			Buff Orpington	3	1,891	8.7	1.4	10.1	29.1
Fresh frozen [1]		Light	[2]	3	1,191	14.0	2.0	16.0	41.2
		Heavy	[2]	3	1,671	15.8	4.4	20.2	36.5
Fresh chilled [1]		do	Rhode Island Red	6	1,785	11.8	4.8	16.6	30.8

[1] Not stored; controls.

[2] Not known.

Interpretation of data on shrinkage and cooking time in relation to storage conditions presents special problems. So far as the writers know, there are no available data on shrinkage and cooking time of chickens that may be used as a measure of experimental error in determining what might be considered significant differences between lot averages. It is believed, therefore, that importance can be attached only to consistent trends over the 3 years when deciding whether shrinkage and cooking time were influenced by storage temperature, drawing of chickens, length of time in storage, weight, and breed of chicken used in the tests.

The system used in interpreting results was to consider only one factor at a time (for example, temperature of storage), to examine the year by year data on this factor in the different groups of undrawn chickens and to calculate averages for the two temperatures for the 3 years. Since the weight and the breed of the chickens were probably operative in all cases, their influence was studied first and considered in relation to the other factors.

The data on shrinkage showed that light stored chickens had less drippings and smaller total losses than heavy stored chickens in a majority of the groups each year. Evaporation loss followed this trend in 1934 and 1935 but varied in relation to weight in 1936. For fresh-frozen and fresh-chilled chickens cooked in 1934 and 1936, the total shrinkage of light chickens was consistently less than that of heavy ones, but in 1934 evaporation and drippings varied somewhat in relation to weight.

In the stored, fresh-frozen, and fresh-chilled chickens, there appeared to be no definite relationship between breed and shrinkage during roasting.

The shrinkage of undrawn chickens did not appear to be affected by temperature of storage. Similarly, drawn and undrawn chickens stored at —20° F. did not differ consistently in shrinkage.

When the shrinkage data were related to the length of storage period, evaporation and total losses of a majority of the lots of chickens were greater at the end of 2 and 3 years than at the end of 1 year, but less at the end of 3 years than at the end of 2. Drippings losses followed the same trend as evaporation and total losses, except in the comparison of 3 with 2 years' storage. Averaged for 1934, 1935, and 1936, the percentages of evaporation losses were 13.6, 16.5, and 14.0, respectively; the percentage of drippings losses, 2.4, 3.2, and 3.1; and the percentage of total losses, 16.0, 19.7, and 17.1. These averages indicate that increasing the period of storage beyond 1 year increased the shrinkage. However, it is doubted whether increasing the period of storage in itself increased the shrinkage of the chickens, because there was no consistent trend in this direction year by year when stored chickens were compared with fresh-frozen and fresh-chilled chickens of the same weight class.

With regard to cooking time as influenced by weight, light chickens in the stored, fresh-frozen, and fresh-chilled lots required more minutes per pound than heavy chickens in a majority of cases each year. The averages for the 18 groups each of stored light and heavy chickens were, respectively, 37.6 and 33.0 minutes per pound.

Barred Plymouth Rocks of the stored lots required each year from 1 to 2 more minutes per pound, on the average, than Buff Orpingtons. The same observation was made in fresh-frozen and fresh-chilled chickens of the two breeds. Since the Barred Plymouth Rocks generally weighed less than the Buff Orpingtons, it would be expected that chickens of the former breed would require more minutes per pound for cooking.

The cooking time of undrawn chickens stored at 0° and —20° F. was not related to the temperature of storage. In chickens stored at —20° the rate of cooking did not appear to be affected by drawing the birds before placing them in storage.

The length of the storage period appears to have influenced the rate of cooking, judging by the majority of the lots and by the averages of 33.3, 37.9, and 34.7 minutes per pound, respectively, for chickens stored 1, 2, and 3 years. However, when the figures for stored chickens are compared year by year with those for fresh-frozen and fresh-chilled chickens of the same weight class, there is evidence that 1 and 3 years of storage resulted in a shorter cooking period, but that 2 years of storage had the opposite effect.

Palatability

The chickens were all carved by the same method so as to furnish comparable samples to the judges. The white-meat samples were taken from the breast. First the skin and subcutaneous fat were removed from the right side of the breast. Next the muscular tissue was cut loose from the wishbone, breastbone, and ribs, across just back of the wing joint, and lifted off to a carving board. Cross sections from one-fourth to one-half of an inch wide and including both pectoralis major and pectoralis minor were cut for the judges. Judge No. 1 was given the portion nearest the wing from each chicken; judge No. 2 the next portion, and so on in order. The breast samples were served while still hot.

The dark-meat samples were taken from the thigh. Skin, subcutaneous fat, and the thigh bone were removed. Cross sections were cut consecutively from the muscular tissue as in the case of the breast muscle, beginning at the end nearest the drumstick. The thigh samples were also served hot, as soon as the breast samples were judged.

The judging committee consisted of five persons, two each from the Bureaus of Animal Industry and Home Economics, and one from the Agricultural Marketing Service. The personnel of the committee varied somewhat in 1934. Three of the judges tested all the samples and two others tested 71 percent. This same group of five judged all samples in 1935 and 1936. In 1934, however, two additional judges acted as substitutes for regular members of the committee. The cooked-meat grading chart of the cooperative meat investigations [10] was used.

The breast and thigh of each chicken were judged for the items shown in table 5. The scores given by the judges for each sample of breast and of thigh for a chicken were averaged separately for each factor as, for example, tenderness.

On the basis of volunteer comments by some of the judges as to flavor of lean meat in the first year's tests, favorable and unfavorable descriptive words were listed, as follows: Favorable—sweet, good chicken flavor; unfavorable—strong, old, stale, rancid, acid, sour, bitter, liver, gizzard, decomposed, foul, abnormal, burned, browned, musty, gluey, acrid, disagreeable aftertaste. All judges were required to use this list of descriptive terms for each chicken in the second and third years' tests.

The results obtained in the palatability studies for the 3 years are presented in tables 5 and 6.

---

[10] United States Department of Agriculture, Bureaus of Home Economics and Animal Industry. Methods of cooking and testing meat for palatability. 36 pp., illus. Revised, 1933. (Mimeographed.)

TABLE 5.—*Palatability* [1] *of breast and thigh samples of chickens after 1, 2, and 3 years of storage at −20° and 0° F., and that of fresh-frozen and fresh-chilled controls, as determined by the cooked-meat grading committee, 1934–36*

BREAST SAMPLES STORED 1 YEAR (1934)

Dressed condition	Storage temperature	Weight group	Breed	Chickens	Aroma		Texture	Flavor of lean		Tenderness	Juice	
					Intensity	Desirability		Intensity	Desirability		Quality	Quantity
	°F.			Number								
Drawn	−20	Light	Barred Plymouth Rock	3	4.7	4.3	6.1	4.6	3.9	6.2	3.1	3.8
			Buff Orpington	3	5.0	4.7	6.2	4.8	4.0	6.4	3.1	3.6
		Heavy	Barred Plymouth Rock	3	4.5	4.7	6.2	5.0	4.6	6.4	2.8	3.8
			Buff Orpington	3	4.9	4.4	6.0	5.0	3.5	6.1	2.9	3.9
Undrawn	−20	Light	Barred Plymouth Rock	3	4.8	4.8	5.9	4.7	4.1	6.5	3.3	4.1
			Buff Orpington	3	4.7	4.6	6.2	4.9	4.6	6.4	3.4	4.0
		Heavy	Barred Plymouth Rock	3	4.7	4.4	5.8	4.9	4.1	6.2	3.2	4.2
			Buff Orpington	3	4.8	5.0	6.0	4.9	4.8	6.4	3.6	4.1
	0	Light	Barred Plymouth Rock	3	4.5	4.9	6.4	4.8	4.2	6.6	3.8	4.3
			Buff Orpington	3	4.6	4.4	6.1	5.2	4.4	6.4	3.7	4.0
		Heavy	Barred Plymouth Rock	3	4.9	4.7	5.8	5.1	4.6	6.6	3.4	3.8
			Buff Orpington	3	4.8	4.7	6.0	5.2	3.8	6.4	3.5	4.1
Fresh frozen [2]		Light	Barred Plymouth Rock	3	5.0	5.1	6.0	4.9	5.4	6.1	3.5	4.2
			Buff Orpington	3	4.8	3.7	5.8	4.6	4.0	6.1	3.4	3.9
		Heavy	Barred Plymouth Rock	3	4.8	5.0	6.3	4.8	5.2	6.4	3.7	4.4
			Buff Orpington	3	4.9	4.9	6.0	4.6	4.9	6.2	3.5	4.1
Fresh chilled [2]		Light	[3]	4	4.6	5.7	6.2	5.0	6.0	6.4	3.2	4.3
		Heavy	[3]	4	4.8	6.0	5.8	4.8	6.1	6.5	3.1	4.0

THIGH SAMPLES STORED 1 YEAR (1934)

Drawn	−20	Light	Barred Plymouth Rock	3	4.8	3.9	5.5	4.7	3.1	5.2	2.9	3.9
			Buff Orpington	3	4.5	3.8	5.7	4.8	3.0	6.0	3.6	4.2
		Heavy	Barred Plymouth Rock	3	4.5	3.9	5.4	4.7	3.1	6.3	2.9	3.8
			Buff Orpington	3	4.6	3.2	5.5	5.0	3.3	6.2	3.8	4.3
Undrawn	−20	Light	Barred Plymouth Rock	3	4.9	2.9	5.7	4.8	3.1	5.8	2.8	3.8
			Buff Orpington	3	4.8	3.7	5.6	5.2	3.1	5.5	3.8	4.4
		Heavy	Barred Plymouth Rock	3	4.5	3.8	5.3	4.7	3.4	5.2	3.1	4.3
			Buff Orpington	3	4.5	4.2	5.4	4.5	3.3	5.4	3.6	3.7
	0	Light	Barred Plymouth Rock	3	4.8	3.9	5.7	5.2	3.0	5.4	3.4	4.4
			Buff Orpington	3	4.8	4.1	5.6	5.4	3.0	5.3	3.8	4.2
		Heavy	Barred Plymouth Rock	3	4.5	4.0	5.4	4.6	2.9	5.9	2.8	4.1
			Buff Orpington	3	4.7	3.9	5.5	4.8	2.9	6.1	3.4	3.9
Fresh frozen [2]		Light	Barred Plymouth Rock	3	4.8	4.3	5.6	4.8	4.3	5.0	2.9	3.8
			Buff Orpington	3	4.6	3.6	5.5	4.9	2.9	5.5	3.6	4.7
		Heavy	Barred Plymouth Rock	3	4.3	4.0	5.9	4.5	4.4	5.8	3.4	4.6
			Buff Orpington	3	4.4	4.4	5.5	4.5	3.7	5.4	3.5	4.3
Fresh chilled [2]		Light	[3]	4	4.5	4.6	5.4	4.8	4.6	5.6	3.7	4.6
		Heavy	[3]	4	4.4	4.9	5.4	4.8	5.1	5.3	3.4	4.4

BREAST SAMPLES STORED 2 YEARS (1935)

Drawn	−20	Light	Barred Plymouth Rock	3	4.9	4.7	5.9	4.7	5.0	6.1	3.7	4.1
			Buff Orpington	3	4.8	4.1	5.9	4.6	4.2	6.3	3.3	4.1
		Heavy	Barred Plymouth Rock	3	4.7	4.3	5.4	4.8	4.4	6.1	3.3	4.1
			Buff Orpington	3	5.0	3.7	6.1	4.8	3.1	6.2	3.0	3.8
Undrawn	−20	Light	Barred Plymouth Rock	3	4.6	4.9	6.0	4.8	4.8	6.2	3.3	4.5
			Buff Orpington	3	4.8	4.9	5.7	4.9	4.4	6.2	3.8	4.3
		Heavy	Barred Plymouth Rock	3	4.9	5.1	5.7	4.9	5.2	6.3	3.3	3.5
			Buff Orpington	3	4.8	4.1	5.9	4.8	4.0	6.2	3.3	4.1
	0	Light	Barred Plymouth Rock	3	4.9	3.7	5.8	4.8	3.8	6.4	3.2	3.9
			Buff Orpington	3	4.8	3.3	5.8	4.9	3.1	5.8	3.3	3.6
		Heavy	Barred Plymouth Rock	3	4.9	3.7	5.8	4.6	4.0	6.0	3.1	3.7
			Buff Orpington	3	4.9	3.9	5.9	4.9	3.4	6.1	3.1	3.3
Fresh frozen [2]		do	Barred Plymouth Rock	3	4.7	5.1	6.1	4.8	4.7	6.2	3.3	4.1
			Buff Orpington	3	4.7	4.4	6.0	4.7	4.6	6.4	3.6	4.3
Fresh chilled [2]		do	Barred Plymouth Rock	3	4.5	4.7	4.9	4.8	5.2	5.9	3.1	3.9
			Buff Orpington	3	4.8	5.3	5.5	5.0	5.2	6.1	3.2	4.2

THIGH SAMPLES STORED 2 YEARS (1935)

Drawn	−20	Light	Barred Plymouth Rock	3	4.7	4.2	5.0	5.1	3.7	5.8	4.5	4.5
			Buff Orpington	3	4.5	3.7	5.2	5.1	3.1	5.9	4.2	4.5
		Heavy	Barred Plymouth Rock	3	4.7	2.7	4.9	5.1	2.7	5.8	3.7	4.1
			Buff Orpington	3	4.8	3.2	5.6	5.1	2.9	6.0	4.3	4.4
Undrawn	−20	Light	Barred Plymouth Rock	3	5.1	2.8	5.1	5.1	3.1	5.4	4.5	4.8
			Buff Orpington	3	4.8	3.5	5.5	4.9	3.1	6.2	4.1	4.7
		Heavy	Barred Plymouth Rock	3	5.0	2.7	4.9	5.3	2.5	5.5	3.9	3.9
			Buff Orpington	3	5.1	2.9	5.5	5.3	2.7	5.9	3.7	4.4
	0	Light	Barred Plymouth Rock	3	4.9	2.9	5.1	5.3	2.3	5.6	4.0	4.4
			Buff Orpington	3	5.1	2.4	5.3	5.6	1.9	5.7	4.0	4.6
		Heavy	Barred Plymouth Rock	3	5.5	2.1	5.1	5.5	1.7	5.5	3.8	4.5
			Buff Orpington	3	5.2	2.1	5.3	5.3	2.1	5.9	4.5	4.1
Fresh frozen [1]		do	Barred Plymouth Rock	3	4.7	3.3	4.9	4.9	4.1	5.3	4.1	4.7
			Buff Orpington	3	4.8	4.1	5.3	5.1	3.9	5.8	4.1	4.6
Fresh chilled [2]		do	Barred Plymouth Rock	3	4.7	4.2	4.5	4.7	4.4	5.1	3.9	4.7
			Buff Orpington	3	4.9	3.8	4.7	4.8	4.0	5.5	3.6	4.3

[1] Maximum score for each item is 7.
[2] Not stored: controls.
[3] Not known.

TABLE 5.—*Palatability*[1] *of breast and thigh samples of chickens after 1, 2, and 3 years of storage at −20° and 0° F., and that of fresh-frozen and fresh-chilled controls, as determined by the cooked-meat grading committee, 1934–36*—Continued

BREAST SAMPLES STORED 3 YEARS (1936)

Dressed condition	Storage temperature	Weight group	Breed	Chickens	Aroma		Texture	Flavor of lean		Tenderness	Juice	
					Intensity	Desirability		Intensity	Desirability		Quality	Quantity
	°F.			Number								
Drawn	−20	Light	Barred Plymouth Rock	3	4.7	4.3	6.1	5.0	4.0	6.2	3.1	3.6
			Buff Orpington	3	4.9	4.4	5.8	5.1	3.5	5.9	3.2	3.5
		Heavy	Barred Plymouth Rock	3	4.9	5.1	6.0	5.0	4.5	6.2	3.2	3.3
			Buff Orpington	3	5.0	4.5	6.1	5.0	3.5	5.9	3.1	3.5
Undrawn	−20	Light	Barred Plymouth Rock	3	4.9	5.1	6.3	4.9	4.9	6.6	3.5	3.7
			Buff Orpington	3	4.9	4.7	5.9	4.9	4.1	6.0	3.5	3.6
		Heavy	Barred Plymouth Rock	3	5.1	4.3	5.5	4.8	3.4	6.0	3.5	3.3
			Buff Orpington	3	4.8	4.6	5.7	4.9	4.0	5.9	3.0	3.4
	0	Light	Barred Plymouth Rock	3	5.1	4.6	6.1	5.1	3.5	6.1	3.1	3.6
			Buff Orpington	3	4.8	3.9	5.7	4.9	3.0	6.0	3.5	3.6
		Heavy	Barred Plymouth Rock	3	5.1	4.9	5.8	4.7	4.1	5.9	3.1	3.3
			Buff Orpington	3	4.9	3.9	5.5	5.1	2.9	5.6	3.4	4.2
Fresh frozen [2]		Light	[3]	3	4.7	4.9	6.3	4.8	4.5	6.3	3.1	3.5
		Heavy	[3]	3	4.9	4.6	5.8	4.9	4.3	5.7	3.1	3.5
Fresh chilled [2]		do	Rhode Island Red	6	4.4	5.7	5.9	4.5	5.7	6.6	3.6	4.2

THIGH SAMPLES STORED 3 YEARS (1936)

Drawn	−20	Light	Barred Plymouth Rock	3	4.9	3.7	5.5	5.2	3.0	5.3	3.9	4.2
			Buff Orpington	3	5.1	3.1	5.4	5.4	2.3	5.7	4.0	4.3
		Heavy	Barred Plymouth Rock	3	4.9	3.8	5.7	5.3	3.7	5.7	3.7	4.0
			Buff Orpington	3	4.9	3.6	5.6	5.3	3.2	5.6	4.1	4.3
Undrawn	−20	Light	Barred Plymouth Rock	3	4.7	3.1	5.7	5.1	2.7	5.4	3.3	3.6
			Buff Orpington	3	5.1	3.3	5.6	5.4	2.6	5.7	3.9	3.8
		Heavy	Barred Plymouth Rock	3	4.6	2.9	5.2	5.2	2.2	5.1	2.8	3.1
			Buff Orpington	3	5.3	2.5	5.3	5.5	2.3	5.5	3.9	3.9
	0	Light	Barred Plymouth Rock	3	5.5	1.3	5.5	6.0	1.3	5.4	3.6	3.5
			Buff Orpington	3	5.3	1.9	5.6	5.7	1.9	5.7	4.0	4.0
		Heavy	Barred Plymouth Rock	3	5.3	2.5	5.5	5.5	1.8	5.7	3.1	3.3
			Buff Orpington	3	5.4	2.1	5.2	5.3	1.9	5.1	4.0	4.2
Fresh frozen		Light	[3]	3	4.5	3.3	5.8	4.9	2.9	5.6	3.6	3.7
		Heavy	[3]	3	5.1	3.3	5.4	5.0	2.4	5.3	3.5	3.9
Fresh chilled [2]		do	Rhode Island Red	6	4.6	4.4	5.5	4.5	4.4	5.5	3.8	4.6

[1] Maximum score for each item is 7.

[2] Not stored; controls.

[3] Not known.

TABLE 6.—*Favorable and unfavorable comments on the flavor of chickens after 2 and 3 years of storage at −20° and 0° F., and those on the flavor of fresh-frozen and fresh-chilled controls, as recorded by the cooked-meat grading committee, 1935–36*

2-YEAR STORAGE (1935)

Dressed condition	Storage temperature	Weight group	Breed	Chickens	Favorable comments		Unfavorable comments	
					Breast	Thigh	Breast	Thigh
	°F.			*Number*	*Number*	*Number*	*Number*	*Number*
Drawn	−20	Light	Barred Plymouth Rock	3	14	5	9	21
			Buff Orpington	3	12	4	15	25
		Heavy	Barred Plymouth Rock	3	13	1	12	27
			Buff Orpington	3	5	5	23	26
Undrawn	−20	Light	Barred Plymouth Rock	3	16	4	10	24
			Buff Orpington	3	8	4	16	21
		Heavy	Barred Plymouth Rock	3	16	3	9	28
			Buff Orpington	3	9	4	17	30
	0	Light	Barred Plymouth Rock	3	7	3	19	26
			Buff Orpington	3	6	1	22	31
		Heavy	Barred Plymouth Rock	3	9	1	19	40
			Buff Orpington	3	7	5	16	36
Fresh frozen [1]	.....	...do...	Barred Plymouth Rock	3	15	8	12	20
			Buff Orpington	3	10	11	17	19
Fresh chilled [1]	.....	...do...	Barred Plymouth Rock	3	17	10	7	10
			Buff Orpington	3	10	11	7	13

3-YEAR STORAGE (1936)

Drawn	−20	Light	Barred Plymouth Rock	3	13	8	20	27
			Buff Orpington	3	9	5	23	35
		Heavy	Barred Plymouth Rock	3	16	10	11	17
			Buff Orpington	3	10	8	23	23
Undrawn	−20	Light	Barred Plymouth Rock	3	14	5	13	35
			Buff Orpington	3	16	4	17	33
		Heavy	Barred Plymouth Rock	3	8	1	30	33
			Buff Orpington	3	12	3	18	35
	0	Light	Barred Plymouth Rock	3	8	1	29	46
			Buff Orpington	3	7	3	24	41
		Heavy	Barred Plymouth Rock	3	13	1	17	37
			Buff Orpington	3	10	2	25	43
Fresh frozen [1]	.....	Light	(?)	3	15	2	15	21
		Heavy	(?)	3	15	4	14	31
Fresh chilled [1]	.....	...do...	Rhode Island Red	6	48	30	11	29

[1] Not stored; controls. Not known.

Interpretation of palatability data in relation to treatment given the chickens also presents problems. Spencer's [11] study of judging is believed to be applicable in a general way, although it did not deal with poultry. From a study of 96 pairs of corresponding left and right legs of lamb judged by 8 persons, Spencer reported an average deviation, within pairs, of 0.3 of a grade for intensity and desirability factors on the cooked-meat grading chart. On this basis it seems logical to require that differences between lot averages should exceed 0.3 of a grade to be of any importance.

Differences between average scores year by year for weight class, breed, dressed condition, and temperature of storage were classified arbitrarily as less than 0.5 of a grade, from 0.5 to 0.9 of a grade, inclusive, and one grade or more. Differences less than 0.5 of a grade between yearly averages for a given factor were considered not to be significant unless these differences occurred in the same direction each of the 3 years and each year followed the direction of a majority of the groups. In this case it was considered to be indicative of a slight trend, not necessarily important. Significance was ascribed to differ-

[11] SPENCER D. A. JUDGING COOKED MEAT. Amer. Soc. Anim. Prod. Proc. 1928: 119–121. 1929.

ences of 0.5 of a grade or more when there was evidence of a consistent trend. Comments were considered to furnish collateral information to scores in all comparisons of flavor.

In all groups of chickens—stored, fresh-frozen, and fresh-chilled—there appeared to be no relation between weight and palatability.

The only factors which gave evidence of breed differences in the stored chickens were desirability of flavor of breast and quality of juice in thigh samples. At the end of the first year there was practically no difference, on the average, in the flavor of the breast samples from the two breeds, but the second and third years' tests each indicated a significant difference in favor of the Barred Plymouth Rocks. Scores for the thigh samples, on the other hand, did not differ sufficiently to indicate that the Barred Plymouth Rocks were preferred in flavor, although this breed received fewer unfavorable comments. Fresh-frozen as well as stored Barred Plymouth Rocks were rated superior to Buff Orpingtons in flavor of breast samples in 1935. In 1934, also, the flavor scores for fresh-frozen chickens suggested a preference for Barred Plymouth Rocks. As shown in the chemical studies, the acidity of the fat tends to increase with storage. Therefore, the Buff Orpingtons may have developed more of an undesirable rancid flavor due to a greater break-down of the fat. In quality, or richness, of juice, a factor directly related to fatness, thighs of the Buff Orpingtons were graded higher than those of Barred Plymouth Rocks in all stored lots tested in 1934 and 1936, but not in 1935.

The effect of the temperature of storage on palatability was found to be significant with respect to desirability of flavor. For this factor both breast and thigh samples rated higher each year for the chickens stored at −20° F. than for those stored at 0°. Differences in flavor were not large enough to be significant in the first year's tests, but they were significant after 2 and 3 years of storage. The greatest difference in flavor associated with storage temperature was observed after 2 years. Scores for intensity of flavor indicated a slight trend toward stronger flavor for thigh samples of chickens stored at 0°.

The temperature of storage also affected desirability of aroma, but less consistently than it did desirability of flavor. In the second year's tests, breast samples of chickens stored at −20° F. were significantly more desirable in aroma than those stored at 0°. In both the second and third years' tests, thighs rated significantly higher for the chickens stored at −20°.

Desirability of flavor and desirability of aroma appeared to be the only factors influenced by full-drawing. In the breast samples, there was a slight but consistent trend toward more desirable flavor in the undrawn chickens. Desirability of aroma also followed this trend, the difference being significant in the second year's tests. In agreement with results from breast samples, thigh samples from undrawn chickens averaged slightly better in flavor than those from drawn chickens at the end of 1 year in storage. At the end of 2 years, however, the thighs of drawn chickens were slightly superior in flavor, and by the end of 3 years there was a significant difference in favor of full-drawing. In desirability of aroma the thighs of drawn chickens were slightly superior on the average in the first year's tests and significantly so in the second and third years.

The length of the storage period appeared to influence breast and thigh samples in the same direction for only three factors of palata-

bility, namely, intensity of aroma, desirability of flavor, and to a lesser degree tenderness. On the average, year by year, there was a slight but consistent trend toward greater intensity of aroma with longer storage. Desirability of aroma of the thigh meat decreased significantly during the second and third years. In both breast and thigh meat, the desirability of flavor also decreased with longer storage. In the breast scores there was a slight trend downward and this was confirmed by the increased number of unfavorable comments. Desirability of flavor of the thighs decreased significantly with an increase in the period of storage. Scores for tenderness of the breast declined slightly, and by the end of 3 years there was a slight downward trend in the thigh scores.

Breast scores for quantity of juice suggested that the meat became slightly drier after 3 years of storage. In quality of juice, thighs improved as the storage period increased.

The general influence of the period of storage on palatability factors of breast and thigh samples was substantiated each year by comparison of the stored chickens with the fresh-frozen and fresh-chilled chickens. Stored chickens had a greater intensity of aroma and flavor than the fresh-frozen and fresh-chilled ones. In desirability of aroma and flavor, stored chickens were inferior to fresh-frozen ones and fresh-frozen to fresh-chilled chickens.

For purposes of general comparison the most important results of the palatability studies on the stored chickens are presented in tables 7 to 9.

TABLE 7.—*Comparison of flavor of chickens of different breeds stored for 1, 2, and 3 years*

[Number of chickens, 18 of each breed each year]

Period of storage (years)	Breed	Flavor[1] desirability of—		Favorable comments on—		Unfavorable comments on—	
		Breast	Thigh	Breast	Thigh	Breast	Thigh
				Number	*Number*	*Number*	*Number*
1	Barred Plymouth Rock	+	+				
	Buff Orpington						
2	Barred Plymouth Rock	++	+	75	17	78	166
	Buff Orpington			47	23	109	169
3	Barred Plymouth Rock	++	+	72	26	110	195
	Buff Orpington			64	25	130	210

[1] +=superiority of less than 0.5 grade; ++=from 0.5 to 0.9 grade, inclusive; +++=1 grade or more.

TABLE 8.—*Comparison of flavor of undrawn chickens stored at −20° and 0° F. for 1, 2, and 3 years*

[Number of chickens, 12 at each storage temperature each year]

Period of storage (years)	Temperature of storage	Flavor[1] desirability of—		Favorable comments on—		Unfavorable comments on—	
		Breast	Thigh	Breast	Thigh	Breast	Thigh
	°F.			*Number*	*Number*	*Number*	*Number*
1	0	+	+				
	−20						
2	0	+++	++	29	10	76	133
	−20			49	15	52	103
3	0	++	++	38	7	95	167
	−20			50	13	68	136

[1] +=superiority of less than 0.5 grade; ++=from 0.5 to 0.9 grade, inclusive; +++=1 grade or more.

TABLE 9.—*Comparison of flavor of drawn and undrawn chickens stored for 1, 2, and 3 years*

[Number of chickens, 12 drawn and 12 undrawn each year]

Period of storage (years)	Treatment	Flavor[1] desirability of—		Favorable comments on—		Unfavorable comments on—	
		Breast	Thigh	Breast	Thigh	Breast	Thigh
				Number	*Number*	*Number*	*Number*
1	Drawn	+	+				
	Undrawn						
2	Drawn		+	44	15	59	99
	Undrawn	+		49	15	52	103
3	Drawn		++	48	31	77	102
	Undrawn	+		50	13	68	136

[1] +=superiority of less than 0.5 grade; ++=from 0.5 to 0.9 grade, inclusive; +++=1 grade or more.

SUMMARY AND CONCLUSIONS

This experiment was conducted from 1933 to 1936 by the Bureaus of Animal Industry, Agricultural Chemistry and Engineering, and Home Economics and the Agricultural Marketing Service, of the United States Department of Agriculture, in cooperation with the Institute of American Poultry Industries. Fattened, plucked cockerels representing light and heavy birds of two breeds, Barred Plymouth Rock and Buff Orpington, were used. These birds were frozen and stored in wooden boxes at 0° and −20° F. under the usual conditions of freezing in refrigerators. A comparison was not made with birds held after they had been frozen under the methods of quick freezing.

One-half of the cockerels stored at the lower temperature were drawn. All those stored at the higher temperature were undrawn. After 1, 2, and 3 years in storage, representative carcasses, together with fresh-chilled and fresh-frozen ones, were examined to determine the effect of the experimental conditions on their quality.

The loss in weight during storage was much higher at 0° than at −20° F. The drawn birds lost more in weight than the undrawn ones stored at the same temperature though the differences were sometimes slight. The loss in weight was approximately the same after 2 years of storage as after 1 year, but was higher after 3 years.

The external appearance of the dressed birds, as indicated by color, bloom, condition of skin, and degree of freezer burn, was adversely affected by increased length of storage. This effect was much more marked at the higher storage temperature.

The amount of glucose in muscle tissue and the acidity of the intraperitoneal fat tended to increase with the length of storage. The results of the other chemical determinations—including moisture in breast muscle and skin, acidity, glutathione, amino nitrogen, and proteinase activity of the aqueous extract of muscle, and proteinase activity of the glycerin extract of muscle—were not affected by the conditions of the experiment.

Considerable numbers of bacteria remained viable in the muscle tissue after 3 years of storage. Anaerobic organisms were present in a smaller percentage of the stored birds than of the fresh birds. However, there was no indication that the bacterial counts were affected by any of the conditions of the experiment.

Light birds required relatively more time for cooking and lost relatively less weight in cooking than the heavy ones.

The palatability of the birds stored at −20° F. was rated better than the palatability of the birds stored at 0° F. The difference was greater after 2 and 3 years of storage than after 1 year. The higher rating was due to a greater desirability of flavor and aroma. There were also more favorable and fewer unfavorable comments by the judges on the flavor of the meat of the birds stored at the lower temperature than at the higher one. The intensity of flavor was higher in thigh meat of birds stored at the higher temperature. The desirability of flavor and aroma was rated better in the breast meat of the undrawn birds, but after 2 and 3 years of storage the thigh meat rated lower in these respects. The desirability of aroma was slightly better in the drawn birds after 1 year of storage and significantly better after 2 and 3 years than in the undrawn birds. The intensity of aroma increased and desirability of flavor decreased with length of storage. Tenderness also tended to decrease with increased storage.

It is concluded that temperatures as low as −20° F. are more favorable to the maintenance of quality in dressed poultry as shown by external appearance and palatability. Drawing apparently has little effect, either favorable or unfavorable, during customary periods of storage, but during more prolonged periods palatability of the thigh meat of poultry is affected adversely if the birds are not drawn.

ORGANIZATION OF THE UNITED STATES DEPARTMENT OF AGRICULTURE WHEN THIS PUBLICATION WAS LAST PRINTED

Secretary of Agriculture	CLAUDE R. WICKARD.
Under Secretary	PAUL H. APPLEBY.
Assistant Secretary	GROVER B. HILL.
Director of Information	MORSE SALISBURY.
Director of Extension Work	M. L. WILSON.
Director of Finance	W. A. JUMP.
Director of Personnel	ROY F. HENDRICKSON.
Director of Research	JAMES T. JARDINE.
Director of Marketing	MILO R. PERKINS.
Solicitor	MASTIN G. WHITE.
Land Use Coordinator	M. S. EISENHOWER.
Office of Plant and Operations	ARTHUR B. THATCHER, *Chief.*
Office of C. C. C. Activities	FRED W. MORRELL, *Chief.*
Office of Experiment Stations	JAMES T. JARDINE, *Chief.*
Office of Foreign Agricultural Relations	LESLIE A. WHEELER, *Director.*
Agricultural Adjustment Administration	R. M. EVANS, *Administrator.*
Bureau of Agricultural Chemistry and Engineering.	HENRY G. KNIGHT, *Chief.*
Bureau of Agricultural Economics	H. R. TOLLEY, *Chief.*
Agricultural Marketing Service	C. W. KITCHEN, *Chief.*
Bureau of Animal Industry	JOHN R. MOHLER, *Chief.*
Commodity Credit Corporation	CARL B. ROBBINS, *President.*
Commodity Exchange Administration	JOSEPH M. MEHL, *Chief.*
Bureau of Dairy Industry	O. E. REED, *Chief.*
Bureau of Entomology and Plant Quarantine	LEE A. STRONG, *Chief.*
Farm Credit Administration	A. G. BLACK, *Governor.*
Farm Security Administration	C. B. BALDWIN, *Administrator.*
Federal Crop Insurance Corporation	LEROY K. SMITH, *Manager.*
Forest Service	EARLE H. CLAPP, *Acting Chief.*
Bureau of Home Economics	LOUISE STANLEY, *Chief.*
Library	RALPH R. SHAW, *Librarian.*
Bureau of Plant Industry	E. C. AUCHTER, *Chief.*
Rural Electrification Administration	HARRY SLATTERY, *Administrator.*
Soil Conservation Service	H. H. BENNETT, *Chief.*
Surplus Marketing Administration	MILO R. PERKINS, *Administrator.*

This bulletin is a joint contribution from

Bureau of Animal Industry	JOHN R. MOHLER, *Chief.*
Bureau of Agricultural Chemistry and Engineering	HENRY G. KNIGHT, *Chief.*
Bureau of Home Economics	LOUISE STANLEY, *Chief.*
Agricultural Marketing Service	C. W. KITCHEN, *Chief.*

U. S. GOVERNMENT PRINTING OFFICE: 1941

For sale by the Superintendent of Documents, Washington, D. C. - - - - - - Price 5 cents

END