Water Absorption by Eviscerated Broilers

During Washing and Chilling

Marketing Research Report No. 438

UNITED STATES DEPARTMENT OF AGRICULTURE
Agricultural Marketing Service • Market Quality Research Division

PREFACE

This study is part of a broad program of research by the Market Quality Research Division of the Agricultural Marketing Service on technical problems in the marketing of poultry. The research was carried on in commercial plants in cooperation with industry in 1958 and 1959.

The Burris Foods Company, Inc., the Grimes and Hauer Poultry Processing Company, the Townsend Poultry Company, and Victor F. Weaver, Inc., supplied facilities and materials. The Poultry Division of AMS assisted in collecting data and E. James Koch of the Agricultural Research Service assisted in analyzing the data.

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October 1960

SUMMARY

Moisture pickup by eviscerated broiler chickens during washing and chilling and moisture losses during draining and shipping were investigated. The chilling methods included the standard tank and four continuous on-the-line systems. Moisture gain was also determined when the neck remained on the carcass and when the thigh area was opened.

Broilers were chilled in tanks for 2, 4, and 24 hours. The continuous on-the-line methods of chilling were the drag, the parallel-flow tumble, the counterflow tumble, and the oscillating vat. The chilling data were first analyzed statistically (excluding the tumble systems), and estimates were then made for all systems.

Statistical analysis revealed that immediately after chilling and before shipping, birds chilled in tanks for 24 hours and in the oscillating vat system showed greatest gains in weight due to moisture absorption. After shipping and second draining, the birds chilled 24 hours still retained the greatest amount of moisture. Birds chilled in the oscillating vat lost a sufficient amount during shipping to retain as low a percentage as those from any system except the continuous drag. Those chilled by the continuous drag usually gained and retained less than those chilled by other systems.

Estimates of water absorbed after the prechill washing revealed that the tumble systems, which employ substantial agitation, appeared to cause a high moisture intake when measurements were made soon after the chilling operation. The moisture appeared to be loosely bound, however, and birds chilled by these continuous methods drained sufficiently during normal commercial handling and shipping so that their apparent gain differed only slightly from that of birds chilled in tanks.

Birds chilled with necks left on absorbed but did not retain substantially more moisture than did those chilled without necks. Cutting open the thigh area during evisceration caused significantly more moisture to be absorbed and retained than leaving the thigh area closed.

WATER ABSORPTION BY EVISCERATED BROILERS DURING WASHING AND CHILLING

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INTRODUCTION

Background

Chilling is an essential stage in processing poultry. The interior portions of the carcass may have a temperature approaching 100°F. immediately after evisceration, and it is important that the temperature be lowered rapidly in order to retard spoilage.

The most common method of chilling eviscerated poultry is to cool it in tanks of slush ice. Agitation may be provided by a water pump or by compressed air. It has been demonstrated amply that tank cooling increases carcass weight (1, 2, 4-12).[1] Bailey and others (1) found that 3.75- to 4-pound birds, halved and eviscerated, averaged 8.2 percent gain in weight during 135 minutes of chilling in agitated slush ice and lost half of this gained weight during overnight storage. Tarver and others (12) reported that 2- to 3-pound eviscerated fryers increased in weight approximately 6 percent in still slush ice, 3 percent in circulated slush ice, and 6 percent in aerated slush ice in 3 to 4 hours; they increased approximately 8 percent in still slush ice and 12 percent in circulated or aerated slush ice in 7 hours. Fromm and Monroe (4) found that eviscerated broilers of 2.66 pounds average weight cooled in air-agitated slush ice for 1 hour increased about 3 percent in weight, for 3 hours 4 percent, for 5 hours 4.7 percent, and for 24 hours 6.5 percent. During storage of the birds in crushed ice in wire-bound crates for 48 hours after chilling, those chilled for 1 hour retained as moisture approximately 2.5 percent of their original weight; those chilled 3 hours 2.5 percent, 5 hours 2.9 percent, and 24 hours 4.0 percent. Lentz and Rooke (9) determined that 2.5- to 3.5-pound fryers gained about 7 percent in 6 hours of immersion in ice water (no agitation), 9.3 percent in 14 hours, and 11.2 percent in 24 hours. It was shown that the birds lost 35 to 55 percent of gained weight in 1 hour of draining, an additional 5 percent in the 2nd hour, and very little thereafter. About half the moisture gained was thus retained.

In addition to length of immersion and degree of agitation, the following factors have been investigated relative to their effect on moisture absorption: Scalding temperature (5, 9, 11); weight, age, and fatness of birds (9, 11, 12); weight (4); and dressing methods (1).

The standard system of chilling in tanks has been replaced or supplemented in many plants by several types of continuous, on-the-line chillers. These chillers, primarily by means of increased agitation of the carcasses, are capable of cooling the birds to below 40°F. in approximately one-sixth to one-half the time required for tank chilling. Work scheduling and efficiency of the total operation can thus be improved.

Purpose

The purpose of this study was to determine the amount of moisture absorbed by eviscerated broiler chickens during washing and during chilling in tanks and in several types of continuous on-the-line chillers in commercial plants. Additional studies included a determination of the effect of the presence or absence of necks on the carcasses and the type of cut used to open the abdominal cavity during evisceration on moisture absorption and retention. An evaluation of moisture pickup in the prechill washers and moisture loss during shipping and handling was also made.

[1] Underscored figures in parentheses refer to items in Literature Cited, page 11.

PROCEDURE

A survey of processing plants was made, and four plants, each using different types of continuous chillers, were selected for the tests.

Chilling

The first plant, designated plant A, used both standard tanks and a continuous in-line "drag" chiller. The standard galvanized steel tanks were approximately 28 inches high, 29 inches wide, and 50 inches long. The sequence involved in filling these tanks was as follows: A 6-inch layer of crushed ice was placed on the bottom of the tank, approximately 800 pounds of chickens were then placed in the tank, the tank was filled with tap water at 41°F. (average temperature), and the tank was "capped" with a final layer of crushed ice. The mixture was agitated by bubbling air through a perforated pipe in the bottom of the tank for the first 60 minutes of the chilling period. Ice was added as required during the chilling period to maintain the cap. Total chilling periods of 2, 4, and 24 hours were tested.

The continuous drag chiller was operated as follows: Eviscerated chickens were hung by the hocks on specially designed shackles, each of which could accommodate 8 to 10 birds. The shackles were attached to an endless line which dragged the birds through a 50-foot trough filled with tap water at 41°F. (average temperature) overflowing at 25 gallons per minute. After this precooling the birds were dragged through 200 feet of slush ice at 32°-33°F. with a 25-gallon-per-minute overflow. The line was curved in the shape of a multiple S so that the total chill area occupied a space 50 feet by 8 feet 4 inches. Partitions were located between the curves of the S to prevent the birds from tangling. The chill water was agitated by forcing air through perforated pipes in the bottom of the tile-lined chill-water enclosure, which was 2 feet 6 inches deep. Crushed ice was fed into the water by an overhead chute. Ice requirements could not be determined because ice was supplied as needed from an ice reserve which was also drawn upon for packing and tank chilling. During the tests the speed of the chill line was such that 58 minutes were required for the cooling of broilers being chilled at the rate of 3,000 birds per hour.

The second plant (plant B) used a parallel-flow tumble system for chilling. The chiller consisted of two metal tanks, in series, each 25 feet 9 inches long, 4 feet 3 inches wide, and 4 feet 2 inches high. A cylindrical drum, suspended in each tank by belts, revolved within the tank and agitated the birds which passed through the drum. The forward motion of the birds was regulated by the rate of flow of the recirculated water within each tank. Thirty-three birds per minute were removed from the first tank automatically by a metal conveyor belt which emptied into the second tank. The first tank used 48°F. tap water flowing at 15 gallons per minute to precool the birds. Ice needs recommended by the manufacturer of the chiller were 0.5 to 0.8 pound of ice per pound of chicken. Time required for the birds to travel through the chiller averaged 18 minutes.

The third plant (plant C) used a counterflow tumble system for chilling. The cooling equipment consisting of two cylindrical drums, each 6 feet 6 inches in diameter, the first 24 feet and the second 28 feet long. A helical drive inside the drums moved the chickens forward. For increased agitation, partitions were attached to the screw portion of the helical drive to lift the birds a few inches above the water level before releasing them as the drums continued to revolve. Overflow water from the second tank at 34°F. was added to the first drum for precooling the poultry. The manufacturer recommended that slush ice be added to the second cylindrical drum at the rate of approximately 0.3 pound of cubed ice per pound of chicken. The cooling operation required 30 minutes when 6,250 birds were chilled per hour.

The fourth plant (plant D) used an oscillating vat system for chilling which consisted of two tanks, the first 15 feet long and 7 feet 5 inches wide and the second tank 30 feet long and 7 feet 5 inches wide. The tanks were rocked from side to side on eccentric rollers which agitated the birds and water during the chilling operation. Tap water at

approximately 57°F. was supplied to the first tank at 32.5 gallons per minute and to the second tank at 6 gallons per minute. The manufacturer recommended that enough ice be used to maintain the temperature of the water in the second tank at 33°-35°F. The forward motion of the birds was regulated by the rate at which the water was recirculated through a return canal fastened to the top of the tank. The cooling process required 40 minutes when the broilers were chilled at the rate of 2,500 per hour.

Prechill Washing

The prechill washers used in the four plants were of the type commercially available. However, direction and pressure of the nozzles varied from plant to plant. Separate lots, each consisting of 25 birds, were used to evaluate moisture gain due to washing. Weighings were made before and after washing.

Controlling Variations

In order to minimize plant-to-plant variation, the following factors were standardized: All birds were scalded at 126°-128°F., had the membrane between the thoracic cavity and neck opened, and were chilled without giblets. The mean carcass weights before washing varied within a comparatively narrow range: The lowest mean weight per bird for a test lot was 2.19 pounds and the highest was 2.49 pounds. The differences between the standard deviations of carcass weights before washing were minor: The lowest standard deviation was 0.24 and the highest was 0.42 pound. Except where variations were purposely introduced, all birds had necks removed and had either one thigh area opened (plants A, C, and D) or two thigh areas opened (plant B) during evisceration. Variation between the same kind of chilling system in different plants was not determinable in this study.

Determining Weight Changes

To evaluate each chilling method, 75 birds were individually tagged with a numbered wing band and were weighed at the following stations: Before washing (dry eviscerated weight), immediately after chilling, after a 30-minute drain, after shipping a distance of approximately 200 miles packed in ice in standard wire-bound wooden crates, and again after draining for 30 minutes after shipping. The last weighing simulated weighing at retail level. To calculate the percentage of moisture pickup, the dry eviscerated weight (weight before washing) was subtracted from the bird weight at each stage investigated (washing, chilling, draining, shipping, and second draining), and each difference in weight was multiplied by one hundred and then divided by the dry eviscerated weight.

Varying Evisceration

To test the effect of presence or absence of necks on the carcasses, 75 additional birds were chilled in the parallel-flow tumble system (plant B) with necks left on. Birds were weighed before washing, after chilling, after a 30-minute drain, after shipping, and again after a second 30-minute drain.

To determine the effect of cutting the area between thigh and rib cage during evisceration, 25 additional birds in which the thigh areas were not opened were selected and tested in the counterflow tumble system (plant C). Weighings were made at the same stations as in the other treatments.

Determining Temperature

The temperature of the deepest portion of the breast muscle of the chickens was taken before chilling, after chilling, and after shipping, using a glass meat thermometer.

RESULTS AND DISCUSSION

Prechill Washing

The gain in weight of broiler chickens during the prechill washing in the four plants is shown in the following tabulation:

	Mean percentage gain[1]
Plant A	2.08 a
Plant B	2.60 b
Plant C	3.25 c
Plant D	2.00 a

[1] Means followed by the same letter or letters are not significantly different at the 5-percent level according to analysis of variance and the multiple range test (3).

The difference between weight gained during washing in plants A and B, A and C, B and C, B and D, and C and D, was significant; that between plants A and D was not.

Because the weight measured after chilling included the moisture pickup from washing, statistical comparisons of chilling methods were limited to tank chilling for 2, 4, and 24 hours and drag chilling in plant A and the oscillating vat system of chilling in plant D.

Washing Plus Chilling

Comparisons based on data in table 1 have been verified by statistical analysis, and statistical significance (at the 5 percent level) is to be inferred where comparisons are made in the following discussion, except where otherwise indicated.

Immediately after chilling, the birds chilled in the drag system showed less pickup than those chilled in the 2-hour tank, those from the 2- and 4-hour tank were median in gain, and those from the 24-hour tank and oscillating vat were highest. When moisture gain was measured after the first 30-minute drain, birds chilled by the drag system were lowest in pickup, those chilled 2 and 4 hours in tanks were median, those chilled in the oscillating vat were slightly higher in gain, and those chilled in tanks for 24 hours absorbed the most moisture. During shipping, the birds from the oscillating vat system lost a substantial amount of moisture; consequently their pickup, measured immediately after shipping, was not different from the pickup of birds from the drag system. Measured after shipping, birds from the drag and oscillating-vat systems gained less than those chilled 2 and 4 hours in tanks, and the birds from the 2- and 4-hour tanks gained less than those chilled 24 hours in tanks. After shipping and a second draining (a stage similar to retail level at which adhering ice has melted and drained), the birds from the drag system showed the least percentage pickup, those from oscillating-vat and 2-hour tank chilling a greater amount, those from the 4-hour tank still greater, and those from the 24-hour tank the greatest pickup of all systems.

When all stages discussed in the foregoing were evaluated as a group, it was usually found that birds chilled by the drag system gained less than did those chilled by any other system, those chilled 2 and 4 hours in tanks and those in the oscillating vat were intermediate in percentage gain, and those from the 24-hour tank gained the most in weight.

Chilling

Estimates of moisture change during chilling and shipping, after the birds had been washed, are presented in table 2 for all the chilling methods studied. The mean percentage gain in weight introduced during the prechill washing (see tabulation above) was subtracted from the mean percentage gain after each process as shown in table 1. This form

of presentation did not lend itself to statistical analysis because different lots of birds were involved in the washer and chiller studies.

When weighed immediately after chilling (table 2), birds chilled 2 and 4 hours in tanks or by the drag system appeared to have the smallest amount of pickup. Birds from the 24-hour tank and oscillating vat systems showed intermediate pickup, and birds from the two tumble systems appeared to absorb the most moisture. After a 30-minute drain, birds from the 2- and 4-hour tanks and drag system were again lowest in gain, those from the oscillating vat slightly higher, those from the 24-hour tank and parallel-flow tumble intermediate, and those from counterflow tumble highest. The picture thus was

TABLE 1.--Moisture absorption by eviscerated broilers, by chilling method[1]

Chilling method	Mean percentage gain in weight measured after[2]--			
	Chilling	1st drain	Shipping[3]	2nd drain
Tank method:	*Percent*	*Percent*	*Percent*	*Percent*
2-hour chill	7.42 b	6.04 b	6.59 b	5.51 b
4-hour chill	6.96 ab	5.96 b	6.81 b	5.97 c
24-hour chill	10.32 c	9.17 d	8.14 c	7.18 d
Continuous drag	6.54 a	5.18 a	5.61 a	4.83 a
Continuous oscillating vat	10.87 c	7.74 c	5.49 a	5.26 b

[1] All with one thigh opened during evisceration; includes gain due to prechill washing.
[2] Within a column, means followed by the same letter or letters are not significantly different at the 5 percent level according to analysis of variance and the multiple range test (3).
[3] Increases in weight during shipping are attributable to adhering ice.

TABLE 2.--Moisture absorption by eviscerated broilers, excluding moisture due to prechill washing, by chilling method[1]

Plant and chilling method	Mean percentage gain in weight measured after--			
	Chilling	1st drain	Shipping[2]	2nd drain
Plant A:				
Tank method:	*Percent*	*Percent*	*Percent*	*Percent*
2-hour chill	5.34	3.96	4.51	3.43
4-hour chill	4.88	3.88	4.73	3.89
24-hour chill	8.24	7.09	6.06	5.10
Continuous drag	4.46	3.10	3.53	2.75
Plant B, parallel-flow tumble	11.10	7.41	5.35	4.73
Plant C, counterflow tumble	15.10	10.28	3.77	3.55
Plant D, continuous oscillating vat	8.87	5.74	3.49	3.26

[1] Birds chilled in parallel-flow tumble system had both thighs opened during evisceration, those chilled in other systems had one thigh opened.
[2] Increases in weight during shipping are attributable to adhering ice.

somewhat different after the birds were drained. For example, although initial pickup was higher in birds from the parallel-flow tumble system than in those from the 24-hour tank, after draining for 30 minutes, birds from both systems were roughly the same in apparent gain. Birds from the 24-hour tank and those from the oscillating vat appeared to pick up substantially the same amount of moisture when measurement was made immediately after chilling, but after a 30-minute drain those from the oscillating vat showed less gain. From these observations it may be surmised that the moisture pickup resulting from extensive soaking such as occurs in 24 hours in a chill tank does not drain from carcasses as rapidly or as extensively as does moisture picked up as a result of relatively short, high-agitation chilling.

When weighed after shipping and after a second 30-minute drain, birds chilled 2 and 4 hours in tanks, or in the drag, counterflow tumble or oscillating vat systems appeared to show a relatively low gain, those from the parallel-flow system a slightly higher gain, and those chilled in tanks 24 hours the highest gain. Again the different draining rates of birds chilled by the different systems had an effect. Probably the fact that birds chilled in the parallel-flow tumble system had two thighs opened accounted for part of their apparently high gain. Birds from most of the continuous systems lost a relatively large amount of moisture during and after shipping, while those chilled in tanks did not.

In general, the pattern appears to be that the standard tank system, when operated so as to chill the birds within 2 to 4 hours, does not introduce an inordinately high gain, but most of the moisture which is picked up is retained during normal commercial handling after chilling. In most continuous systems, which involve a substantial amount of agitation of the carcasses, the moisture pickup when measured soon after chilling may be very high, but the moisture seems to be quite loosely bound, and very extensive draining appears to occur during normal commercial handling. Measured after shipping and draining, birds chilled by continuous methods usually had gained not much more moisture, and sometimes less, than birds chilled by the standard tank method.

Modification of Eviscerating Cut

When necks were removed from the carcasses before washing and chilling in the parallel-flow tumble system, smaller amounts of moisture were picked up than when necks were left on. However, after normal shipping and handling procedures, this difference became negligible (table 3).

In contrast, however, the effect of cutting the area between the thigh and rib cage when opening the body cavity during evisceration was of major significance (table 4). When one thigh area was cut open prior to washing and chilling in the counterflow tumble

TABLE 3.--Moisture absorption by eviscerated broilers with and without necks[1]

Treatment	Percentage gain in weight measured after--				
	Washing	Chilling[2]	1st drain	Shipping	2nd drain
	Percent	*Percent*	*Percent*	*Percent*	*Percent*
With necks	4.06	18.03	12.46	8.26	7.94
Without necks	2.60	13.70	10.01	7.95	7.33
Level of significance of difference	0.1	0.1	0.1	not sig.	10.0

[1] All with both thighs opened during evisceration.
[2] Parallel-flow tumble system.

TABLE 4.--Moisture absorption by eviscerated broilers with one or no cut in thigh area.

Treatment	Percentage gain in weight measured after[1]--			
	Chilling[2]	1st drain	Shipping	2nd drain
	Percent	*Percent*	*Percent*	*Percent*
No thigh area cut.....	12.21	8.45	5.25	5.14
One thigh area cut.....	18.35	13.53	7.02	6.80

[1] The difference at each stage was statistically significant at the 0.1% level according to analysis of variance.

[2] Counterflow tumble system.

system, the carcasses gained and retained a significantly and substantially greater percentage of moisture than did the carcasses in which the thigh areas remained closed. The results reported by Kotula and others (8) are thus substantiated and expanded by the field data reported here.

Temperature

In all plants except Plant B, the birds were chilled to 40°F. or below. In Plant B, because of inadequate amounts of ice, the carcass temperatures averaged slightly above 40°F. After shipping, carcass temperatures of the birds from all plants averaged approximately 33°F.

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