THE RELATIONSHIP OF TIME AND TEMPERATURE IN THE REMOVAL OF FEATHERS DURING THE PROCESSING OF BROILERS

By

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THESIS AND ABSTRACT APPROVED:

George W. Newell
Thesis Advisor

R. B. Thompson
Faculty Representative

Robert MacVicar
Dean of the Graduate School

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INTRODUCTION

The scalding temperatures used by commercial processors throughout the country have a wide and varied range. In addition to temperature, the time that broilers are submerged in water prior to picking is a governing factor in determining the quality of the finished product and is also subject to differences. Extensive research has not been done on this problem and only a minimum of scientific data could be found that was a result of experimentation and included the major correlated possibilities of time and temperature.

In order to test the effect of time and temperature on feather removal it is highly improbable to arrive at every mathematical combination. Although not all temperatures and times of scalding were tested, a wide enough range was used so that the desired treatment would be within the range used.

The objectives of this investigation were as follows:

1. To determine the change in temperature of a broiler immediately after killing.

2. To determine the force required to pull feathers from broilers when scalded at different temperatures and for different lengths of time.

3. To determine the amount of cuticle removed from broilers when scalded at different temperatures and for different lengths of time.

REVIEW OF THE LITERATURE

The body temperature of chickens ranges between 105.0 and 109.5 degrees F. according to Barger and Card (1949). No information could be found regarding the change in temperature immediately after killing. The question as to how long a broiler may be held at normal room temperature after killing has stimulated experimentation of this nature.

Experimentation on time and temperature of scalding has come into being more frequently in the last few years. The earliest literature cited was Stewart and Drews (1938) who found that the ideal temperature for scalding broilers was in water ranging between 126 and 130 degrees F. Birds were kept in water fifteen to twenty seconds.

Roberts and Robinson (1939) found that slack scalding at a temperature of 129 to 130 degrees F. secured a cleaner better picked bird than those scalded at other temperatures. Scalding broilers at 138 to 150 degrees F removes the epidermis. The removal of epidermis gave rise to discoloration due to unevenness in the evaporation of moisture from the birds. Birds scalded and then cooled at 127 degrees F. had better market appearance than those scalded at 145 degrees F. and then cooled.

Processors have refrained from using temperatures above 140 degrees F. because of cuticle loss. Gwin (1951) stated that there is a very critical temperature beyond which one

cannot go and that temperature is somewhere near 142 degrees F. The protein of the skin coagulates causing it to break down rapidly in marketing channels. However, Hausen (1946) recommended extremely high scalding temperatures. Birds were immersed in water ranging from 158 to 164 degrees F. depending on the size of the bird. The approximate length of time birds were scalded was three and one half seconds.

Pearce and Lavers (1949) varied the scalding time and temperature for chickens and found that the force required to pull feathers ranged from fifteen ounces for thirty seconds at 125 degrees F. to five ounces for fifteen seconds at 136 degrees F. Damage to the skin by mechanical pickers was shown to increase as scalding temperatures increased.

Pool, Mecchi, Lineweaver, and Klose (1954) did similiar work with turkeys. It was found that variation of scalding time from thirty to 120 seconds for 125 degrees F. scald produced no statistically significant difference in feather pulling force. Within the normal range of variation of time and temperature, time is obviously much less critical than temperature in establishing the effect of scalding on feather release. Altered skin appearance and storage characteristics are evident at 140 degrees F. but provide a pin free, inexpensive operation. A normal skin appearance and ordinary storage characteristics are insured at 126 degrees F. but only at the expense of either increased pinning costs or undesirable amounts of pin feathers on the finished product. The amount

of residual feathers on the machine picked turkey was shown to be directly related to the force required to pull individual feathers and both of these quantities were inversely related to the temperature of scalding. There was a marked decrease in residual pin feathers when the time was increased from thirty to sixty seconds.

The equipment used in the above experiment was a spring balance to which a hemostat clamp for grasping individual feathers was attached. Pool (1955) stated that the equipment now used at the same laboratory for similar work is a recording system requiring a strain gage, an amplifier and physiological recorder.

Previous work on cuticle removal has been for the most part limited. The sub scald method of immersing birds in water is closely associated with the amount of surface cuticle removed by the picker. Gwin (1950) stated that the sub scalding is the temperature which permits removal of the feathers and pin feathers with the greatest of ease yet affects only the thin outer layer of skin. Dressing at a slack scald temperature, below 129½ degrees F., will not usually loosen the outer layer of skin enough to cause the mechanical pickers to partially remove it. At temperatures between 137 and 139 degrees F. the outer layer of skin blisters enough to be completely removed by the mechanical pickers.

Parnell, Butler, and Cover (1950) compared the quality of fryers scalded at 126 degrees F. for seventy seconds with those scalded at 145 degrees F. for ten seconds. Practically

all of the fryers scalded at the lower temperature were classified as Grade A while those scalded at 145 degrees F. were all Grade C because of numerous skin abrasions. After storage periods of three to six months in an unwrapped frozen condition, most of the 145 degree F. scald birds were classified as rejects due to severe surface dehydration, while none were rejected from the 126 degree F. group.

Tests concerning the cuticle removal of turkeys was performed by Lineweaver and Klose (1952). They discovered that turkeys scalded at temperatures ranging between 130 degrees F. and 138 degrees F. did not process well. Parts of the cuticle remained and pin feathers were apparent.

METHODS AND MATERIAIS

The first objective of this experiment was to determine the change in body temperature of a broiler prior to and immediately after killing. In order to obtain the temperature at the base of the feather an iron constantin thermocouple and a potentiometer were used. It was found that accurate temperatures could be obtained by inserting the thermocouple in the base of a mature feather. By making a small hole in the shaft of the feather the thermocouple could be easily inserted for temperature determination. One other problem which had to be overcome was keeping the thermocouple in the feather during the struggling of the bird. This was accomplished by taping the thermocouple wires to a straightened fish hook. The barb of the hook was inserted into the skin of broilers along side of the feather to be used. In this manner the thermocouple remained in the shaft of the feather and the temperatures taken at this point.

For this portion of the test, temperatures were determined on eleven males and ten females. Broilers used throughout the entire experiment were all New Hampshires and were of approximately the same age and size. Feathers in the hip section of the back were used since previous work had shown the feather pulling force of those feathers to be the first indicator of scalding efficiency.

The second objective was to determine the force required to pull feathers from broilers when scalded at different temperatures and for different lengths of time. The birds were killed by cutting in a semi kosher manner, which is a cut along the juglar vein, and allowed to bleed freely. The birds after bleeding thoroughly and no longer showing signs of life were submerged manually in a commercial thermostatically controlled tank. Timing of broilers submerged in water was done with a sweep second hand watch. After the prescribed time the bird was taken to a scale from which a hemostat was suspended. Ten birds per specific time and temperature were used and there was an equal distribution of males and females per scald. Ten mature feathers were selected from the base of the bird's back region in a given area, one at a time, and clamped tight by the hemostat. The bird was then drawn to the point where the feather pulled free. Only those feathers free from blood and showing no evidence of being young feathers were used. A total of 450 birds were used and the entire group of birds was completely randomized as to the order of selection.

Thirteen different temperature gradients and eight time changes were established making a combined total of forty-five different time and temperature scalds. The temperatures ranged from 110 degrees F. to 160 degrees F. at five degree intervals. There were two additional temperature ranges,

138 degrees F. and 128 degrees F., primarily because they appeared frequently in the literature and were accepted by many as being ideal temperatures.

The birds were all hatched at the same date, fed the same ration, housed in similar surroundings, and had the same amount of floor space per bird. Twenty males and twenty females were selected at random and weighed. The average weight of the males was 3.2 pounds and the females 2.7 pounds. Each bird was not weighed before it was used but those birds that appeared to be abnormally small or abnormally large were discarded and replaced.

The third objective of this investigation was to determine the amount of cuticle removed from broilers when scalded at different temperatures and for different times of scalding. A mechanical hand picker was used. The birds were held by the shank and rotated in a set course for a period of fifteen seconds. Regardless how many feathers remained on the bird it was graded for the amount of surface cuticle removed. Birds were graded visually and the grade reported was an average grade of three graders.

The grades ranged from one through ten as follows:

Grade	1----------	0	to	10%	of	the	cuticle removed
"	2----------	10	to	20%	"	"	" "
"	3----------	20	to	30%	"	"	" "
"	4----------	30	to	40%	"	"	" "
"	5----------	40	to	50%	"	"	" "
"	6----------	50	to	60%	"	"	" "
"	7----------	60	to	70%	"	"	" "
"	8----------	70	to	80%	"	"	" "
"	9----------	80	to	90%	"	"	" "
"	10----------	90	to	100%	"	"	" "

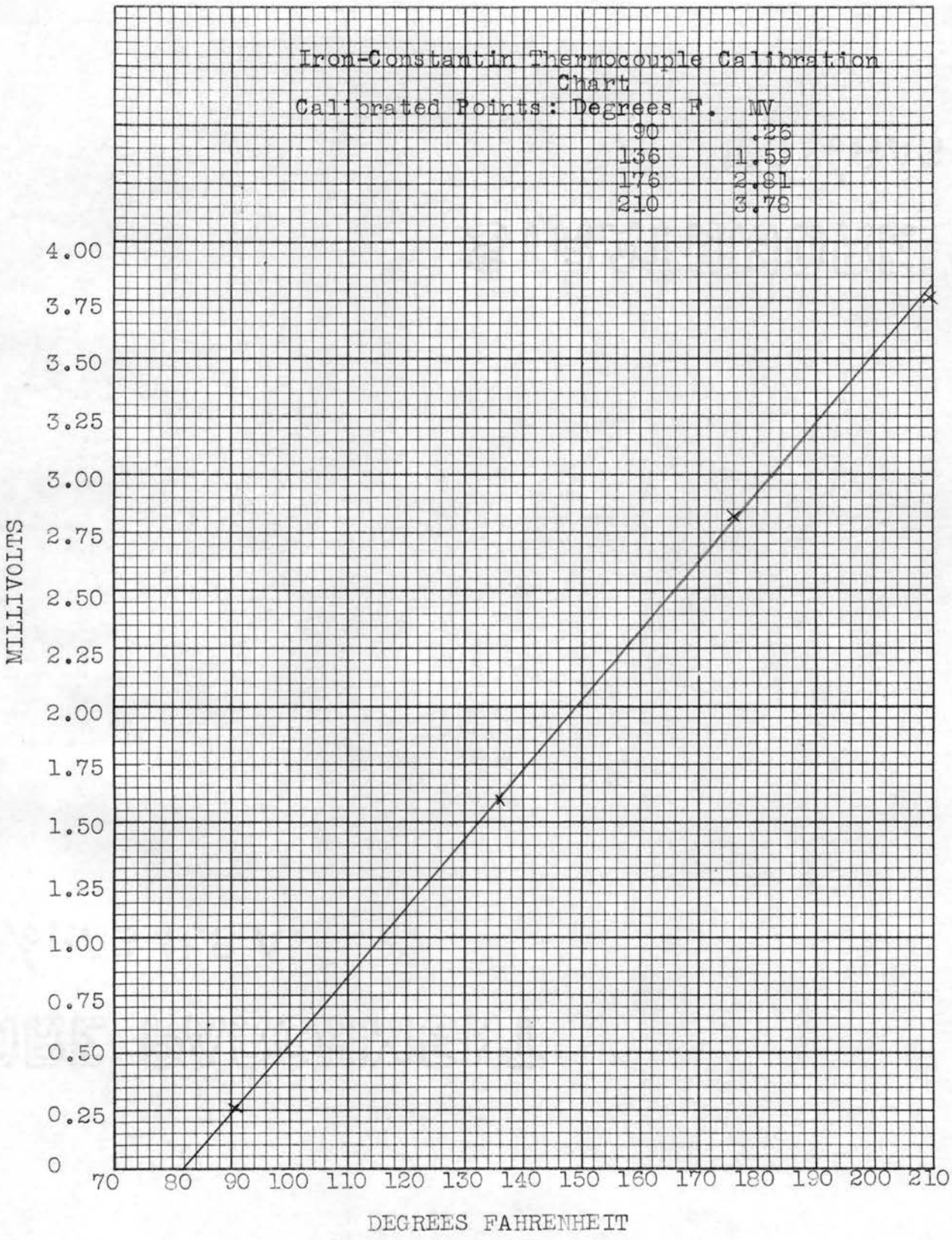

Iron-Constantin Thermocouple Calibration Chart
Calibrated Points: Degrees F. MV
90 .26
136 1.59
176 2.81
210 3.78
MILLIVOLTS
4.00
3.75
3.50
3.25
3.00
2.75
2.50
2.25
2.00
1.75
1.50
1.25
1.00
0.75
0.50
0.25
0
70 80 90 100 110 120 130 140 150 160 170 180 190 200 210
DEGREES FAHRENHEIT

FIGURE 1

RESULTS

Loss of Body Temperature After Killing

The temperatures at the base of the feather as determined for the 21 broilers used are listed in Table 1. The average temperatures at 5, 10, 15, 30 and 40 minutes after killing are plotted in Figure 2. Temperatures ranging from 106.5 degrees F. to 108.0 degrees F. were obtained for the live birds. These temperatures are in very close agreement with the body temperatures for chickens as reported by Barger and Card (1949).

Temperatures recorded at intervals of 5, 10, 15, 30, and 40 minutes after killing indicate that the loss of body heat is a slow process. Five minutes after killing the temperature at the base of the feather of six of the birds had not changed. For the other 15 birds a temperature drop of 0.5 to 1.0 degrees F. was noted. An average of 0.53 degrees F. drop in temperature was found for the 21 birds. Ten minutes after killing an average of 0.93 degrees F. drop in temperature, 107.38 to 106.45 degrees F., was recorded with only one bird of the 21 showing as much as a two degree change.

Fifteen minutes after killing the average temperature was 105.88 degrees F., a drop of 1.5 degrees F. During this time the maximum change by any of the chickens was a drop of four degrees. The rate of loss during the period from 15 to 30 minutes is much slower than it was during the first 15 minutes. An average of only 0.14 of a degree was recorded for

this period with 16 of the birds showing no temperature change.

The rate of temperature change is more rapid from 30 to 40 minutes after killing than during the previous 15 minutes although not as rapid as the first 15 minutes. The temperature changes for these three periods are 0.26 degrees F., 30 to 40 minutes; 1.5 degrees F., 0 to 15 minutes; 0.14 degrees F., 15 to 30 minutes respectively. The total change in temperature, 40 minutes after killing, was 1.9 degrees F., an average decrease from 107.38 to 105.48 degrees F.

The Force Required to Pull Feathers from Broilers When Scalded at Different Temperatures and Different Lengths of Time

The force in grams necessary to pull the feathers from broilers covers a wide range. The results as determined for the various scalding times and temperatures are recorded in Tables 2 and 3. The data in Table 2 has been segregated according to water temperature. The times that birds were in the water are shown for each temperature for comparison purposes. Table 3 groups the water temperatures and feather pulling force according to the length of time in water.

A comparitive perspective of all the times and temperatures of scalding in relation to feather pulling force is shown in Figures 9 and 10. The curve drawn is an average of the entire range and includes all the points plotted.

The feather pulling force at 110 degrees F. was approximately the same as that of 120, 90, and 60 seconds. The males had an average feather pulling force of 387, 384, and 377 grams respectively. The feather pulling force of females was 321, 313, and 331 grams at the same three lengths of time. The feather pulling force of males ranged from 46 to 66 grams higher than that of females.

At 115 degrees F. the feather pulling force at 120 seconds was 321 grams for the males and 308 for the females. The feather pulling force increased to 379 for the males and 322 grams for the females when the scalding time was reduced to 90 seconds. The greatest feather pulling force in the entire test was recorded at 60 seconds. The males had an average feather pulling force of 399 and the females 347 grams.

There was only a four gram difference between males and females at 120 degrees F. for 120 seconds. Males had an average feather pulling force of 254 as compared with 250 grams for females. At 90 seconds the greatest feather pulling force was recorded for the 120 degree F. group. The males had an average feather pulling force of 345 and the females 313 grams. A decrease of about ten grams was noted for each sex at 60 seconds as compared with those scalded for 90 seconds. The average feather pulling force was 335 and 301 grams for the males and females.

There was a sharp decline in the feather pulling force at 125 degrees F. for 90 seconds as compared with the nine previously discussed time and temperature groups. The males had a feather pulling force of 176 grams which was 51 grams greater than the females average of 125. At 60, 45, and 30 seconds there was a slight increase in feather pulling force of both sexes as the time in the water decreased. At 60 seconds the males had a feather pulling force of 225 grams while the females were almost as high at 219 grams. A difference of 24 grams was found in males immersed for 45 and 30 seconds for which the values were 261 and 285 grams. The force necessary to pull the feathers of females was almost identical at times of 45 and 30 seconds, averaging 232 and 233 grams.

The feather pulling force at 128 degrees F. for 90 seconds was in close agreement with 125 degrees F. for the same time. However, the feather pulling force at 128 degrees F. was lower at the other times of scalding. Male feathers had a greater average feather pulling force, ranging from 36 to 54 grams, than females. Slight differences were noted at 60, 45, and 30 seconds for males with feather pulling forces of 185, 179, and 190 respectively. When the females remained in the water for 90 and 60 seconds the force required to pull the feathers was almost the same, 134 and 131 grams. Females scalded for 45 and 30 seconds showed comparitive results, 149 and 156 grams, but a marked difference from the 90 and 60 second groups.

At 130 degrees F. for 90 seconds the feather pulling force for males averaged 135 grams and for the females 120 grams. Males and females at 60 and 45 seconds averaged almost identical feather pulling forces with females only two grams higher, 177, than males, 175, for the 60 second period. The feather pulling force for the males at 130 degrees F. for 30 seconds shows a definite increase over the other times of scalding at this temperature. At the same time there was a substantial decrease in the feather pulling force of females. Males averaged 201 and females only 141 grams.

At 135 degrees F. there was a difference of 27 grams in the males between the longest and shortest scalding time. Females registered a 19 gram difference. The greatest feather pulling force at 135 degrees F. was recorded at 30 seconds and exceeded the feather pulling force of those broilers scalded for 15 seconds.

Small variation was noted at 138 degrees F. for the four time periods for males. A difference of only 15 grams was noted between males scalded at 60 and 15 seconds. Females scalded for 60 seconds had a feather pulling force of 105 grams which exceeded the feather pulling force of males at the same length of scalding. This likewise exceeded the pulling force of males scalded at the lesser times of scalding.

The feather pulling force at 140 degrees F. for 60 seconds dropped to 47 grams for males and 40 grams for females. There was almost no difference at 45 seconds for females as the average feather pulling force was 42 grams. The feather pulling force for males increased uniformly as the time of scald decreased. Females also increased at 30 and 15 seconds. The feather pulling force for males averaged greater than females at all time intervals ranging from 7 to 27 grams.

At 145 degrees F. the feather pulling force for males was 24, 33, and 47 grams at 30, 20, and 10 seconds respectively. The females average feather pulling force was 19, 17, and 51 for the same times.

The feather pulling force was 7 grams for males and 8 grams for females at 150 degrees F. for 30 seconds. It increased to 17 and 40 grams for males at 20 and 10 seconds. Females increased in feather pulling force to 13 and 40 grams at 20 and 10 seconds. One hundred and fifty degrees F. for 10 seconds was the only time and temperature scald that both males and females averaged the same feather pulling force.

The difference between males and females at 155 degrees F. was slight at all time intervals. There was a marked difference between different times of scalding as the males recorded 7, 11, and 28 grams at 30, 20, and 10 seconds. The females averaged 5, 13, and 25 grams for the same times of scalding.

At 160 degrees F. for 30 seconds the males had an average feather pulling force of 9 and females only 4 grams. Fourteen and 13 grams were averaged for males and females at 20 seconds. Females averaged higher than males at 10 seconds having a feather pulling force of 32 while males averaged 28 grams.

A positive relation of time and temperature in regard to feather pulling force was statistically significant for certain groups at both the 95 and the 99 per cent confidence level. The results of the trials tested are shown in Figures 3, 4, 5, and 6. Any two time and temperature scalds bracketed by the same bracket are not significantly different at the chosen confidence level. Any two time and temperature scalds not bracketed by the same bracket are significantly different at the chosen confidence level. On numerous occasions brackets of a time and temperature scald overlap groups of preceeding and/or succeeding time and temperature scalds. In Figure 3 the first two brackets illustrated at the top of the page embracing the different time and temperature scalds are completely independent and are significantly different from the other brackets. The next two brackets, however, overlap each other. Scalds at 125 degrees F. for 30 seconds and 125 degrees F. for 45 seconds are not significantly different from each other but scalds at 125 degrees F. at 30 seconds and 120 degrees F. for 120 seconds are significantly different at the 95 per cent level. Scalds

at 125 degrees F. for 45 seconds are not significantly different from either of the above mentioned two scalds although they both are significantly different from each other .

The Amount of Cuticle Removed from Broilers When Scalded at Different Temperatures and For Different Lengths of Time

Table 4 shows the average grade of the cuticle removal of all broilers scalded at specific times and temperatures. This is graphically illustrated in Figures 7 and 8. Average grades are plotted for each temperature group. Figure 8 is a magnification of Figure 7 and includes those temperatures ranging from 128 degrees F. to 145 degrees F. since that is the area of greatest change.

Broilers scalded at temperatures of 125 degrees F. or less regardless of the length of time submerged in water had all of the cuticle left on the bird after picking. Scalding at 128 degrees F. for 90 and 60 seconds resulted in portions of the cuticle along the breast bone being removed and with average grades of 1.8 and 1.6 being recorded. No "barking" or cuticle removal occurred at times of 45 and 30 seconds. Average cuticle grades of 2.0 were recorded at 130 degrees F. for 60 and 45 seconds. Birds scalded for 90 seconds had an average grade of 2.1 while those scalded for 30 seconds averaged 1.8.

There was a wide range of cuticle grade at 135 degrees F. among the different scalding times. Birds scalded for 60

and 45 seconds had approximately the same grade, 8.2 and 8.4 respectively. At 30 seconds the average grade was 5.2 and at 15 seconds the average grade was 2.8.

A majority of the entire cuticle was removed at 138 degrees F. at all scalding times. Birds scalded for 15 seconds had an average grade of 7.5 as compared to 9.2 for those scalded for 30 seconds. At times of 60 and 45 seconds the entire cuticle was removed from all birds tested. Scalds at 140 and 145 degrees F. at all time intervals resulted in grades of 9 and 10. No individual bird was graded lower than 9 and most of the birds were graded 10. A grade of 10 was recorded for all birds scalded at 150 degrees F. and above and for the three different scalding times.

Table 1

THE TEMPERATURE AT THE BASE OF THE FEATHER OF NEW HAMPSHIRE BROILERS, DEGREES FAHRENHEIT

Bird No.	Live bird	Minutes after killing 5	10	15	30	40
1	107.5	107.0	107.0	106.0	106.0	106.0
2	107.0	107.0	106.5	105.0	105.0	104.0
3	108.5	107.5	107.0	107.0	107.0	107.0
4	107.5	107.0	106.0	105.0	105.0	105.0
5	106.5	106.5	106.0	106.0	106.0	106.0
6	107.5	106.5	106.5	106.0	105.0	105.0
7	107.0	107.0	106.5	106.5	106.0	105.0
8	108.0	107.0	107.0	106.5	106.5	106.5
9	107.0	106.0	105.0	105.0	104.5	104.5
10	107.5	107.0	107.0	106.0	106.0	106.0
11	107.0	106.5	106.0	106.0	105.5	105.0
12	107.0	106.5	106.5	106.0	106.0	106.0
13	107.5	107.5	107.0	106.0	106.0	105.5
14	107.0	106.0	105.5	103.0	103.0	103.0
15	107.5	107.0	107.0	106.5	106.5	106.5
16	107.5	107.5	107.0	107.0	106.5	106.0
17	107.5	106.5	106.0	106.0	106.0	106.0
18	108.0	107.0	106.5	106.0	106.0	105.0
19	107.0	106.5	106.5	106.0	106.0	106.0
20	107.5	107.5	107.0	106.0	106.0	105.0
21	107.5	107.0	106.0	106.0	106.0	106.0
Average	107.38	106.85	106.45	105.88	105.74	105.48
Average loss from live bird		.53	.93	1.50	1.64	1.90

Table 2

FORCE REQUIRED IN GRAMS TO PULL FEATHERS AT DIFFERENT TEMPERATURES AND FOR DIFFERENT TIMES OF SCALDING

Temperature (degrees F.)	Time (seconds)	Male (grams)	Female (grams)
110	120	387	321
110	90	384	313
110	60	377	331
115	120	321	308
115	90	379	322
115	60	399	347
120	120	254	250
120	90	345	313
120	60	335	301
125	90	176	125
125	60	225	219
125	45	261	232
125	30	285	233
128	90	170	134
128	60	185	131
128	45	179	149
128	30	190	156
130	90	135	120
130	60	175	177
130	45	177	176
130	30	201	141
135	60	137	120
135	45	123	128
135	30	150	139
135	15	135	121

Table 2 (continued)

Temperature (degrees F.)	Time (seconds)	Male (grams)	Female (grams)
138	60	102	105
138	45	113	78
138	30	110	89
138	15	117	101
140	60	47	40
140	45	53	42
140	30	88	61
140	15	102	95
145	30	24	19
145	20	33	17
145	10	47	51
150	30	7	8
150	20	17	13
150	10	40	40
155	30	7	5
155	20	11	13
155	10	28	25
160	30	9	4
160	20	14	13
160	10	28	32

Table 3

FORCE REQUIRED IN GRAMS TO PULL FEATHERS AT DIFFERENT TEMPERATURES AND FOR DIFFERENT TIMES OF SCALDING

Time (seconds)	Temperature (degrees F.)	Male (grams)	Female (grams)
120	110	387	321
120	115	321	308
120	120	254	250
90	110	384	313
90	115	379	322
90	120	345	313
90	125	176	125
90	128	170	134
90	130	135	120
60	110	377	331
60	115	399	347
60	120	335	301
60	125	225	219
60	128	185	131
60	130	175	177
60	135	137	120
60	138	102	105
60	140	47	40
45	125	261	232
45	128	179	149
45	130	177	176
45	135	123	128
45	138	113	78
45	140	53	42
30	125	285	233
30	128	190	156
30	130	201	141
30	135	150	139
30	138	110	89
30	140	88	61
30	145	24	19

Table 3 (continued)

Time (seconds)	Temperature (degrees F.)	Male (grams)	Female (grams)
30	150	7	8
30	155	7	5
30	160	9	4
20	145	33	17
20	150	17	13
20	155	11	13
20	160	14	13
15	135	135	121
15	138	117	101
15	140	102	95
10	145	47	51
10	150	40	40
10	155	28	25
10	160	28	32

Table 4

AVERAGE VISUAL GRADE OF CUTICLE REMOVED FOR BROILERS SCALDED AT DIFFERENT TEMPERATURES AND FOR DIFFERENT TIME INTERVALS

Temperature (degrees F.)	Time (seconds)	Grade
110	120	1
110	90	1
110	60	1
115	120	1
115	90	1
115	60	1
120	120	1
120	90	1
120	60	1
125	90	1
125	60	1
125	45	1
125	30	1
128	90	1.8
128	60	1.6
128	45	1
128	30	1
130	90	2.1
130	60	2
130	45	2
130	30	1.8
135	60	8.2
135	45	8.4
135	30	5.2
135	15	2.8
138	60	10
138	45	10
138	30	9.2
138	15	7.5
140	60	10
140	45	10
140	30	9.9
140	15	9.4
145	30	10
145	20	10
145	10	9.6
150	30	10
150	20	10

Table 4 (continued)

Temperature (degrees F.)	Time (seconds)	Grade
150	10	10
155	30	10
155	20	10
155	10	10
160	30	10
160	20	10
160	10	10

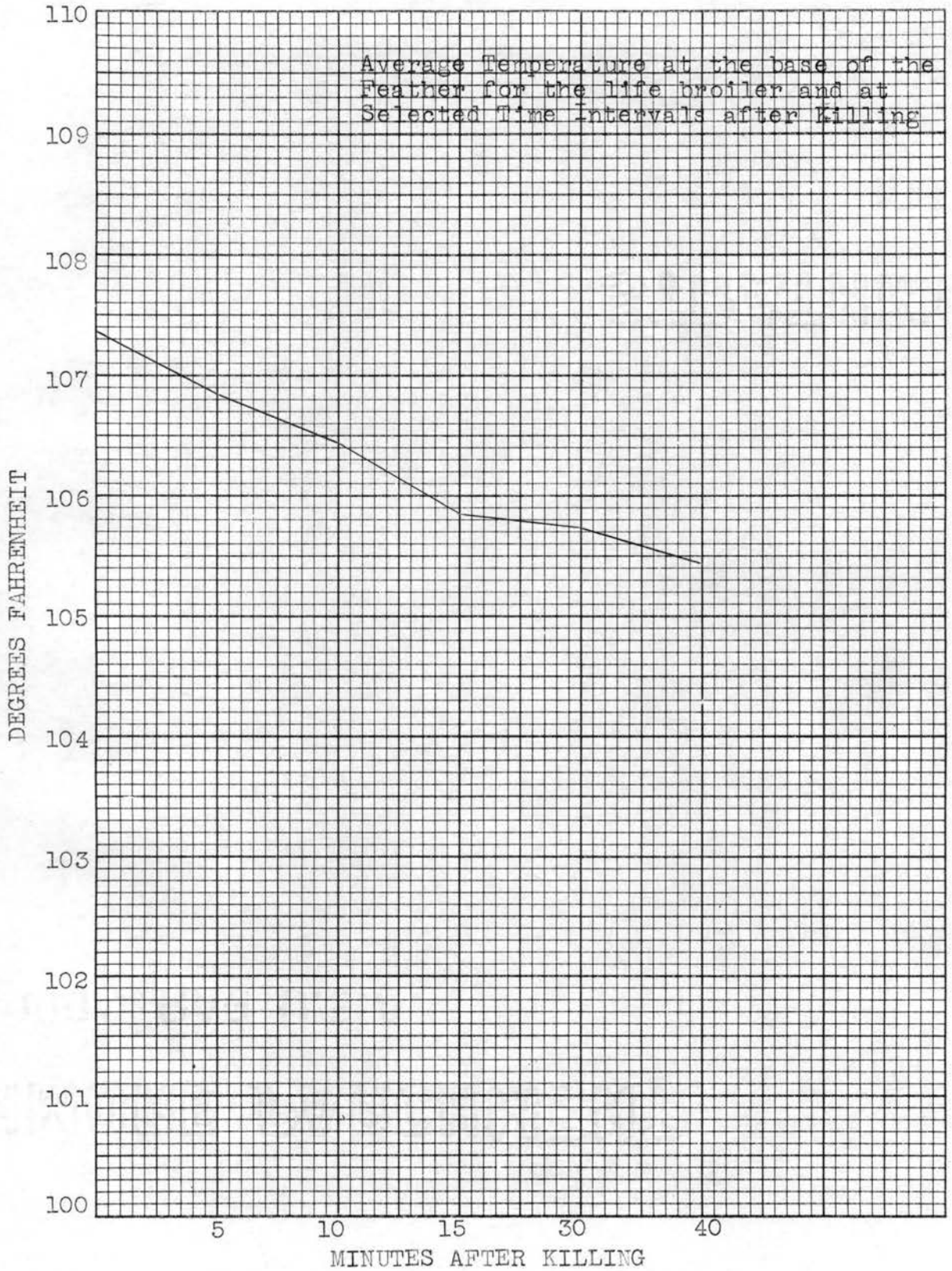
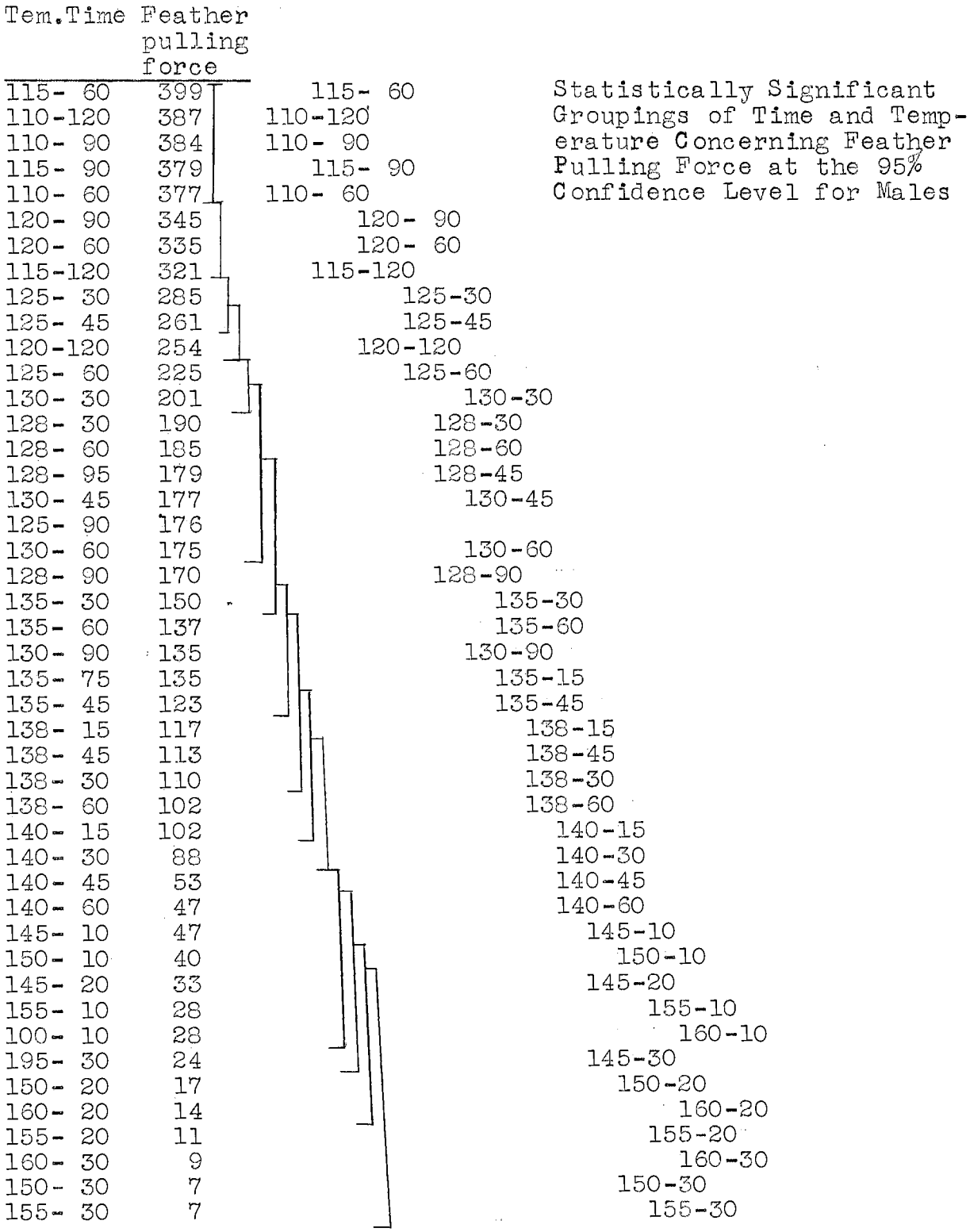
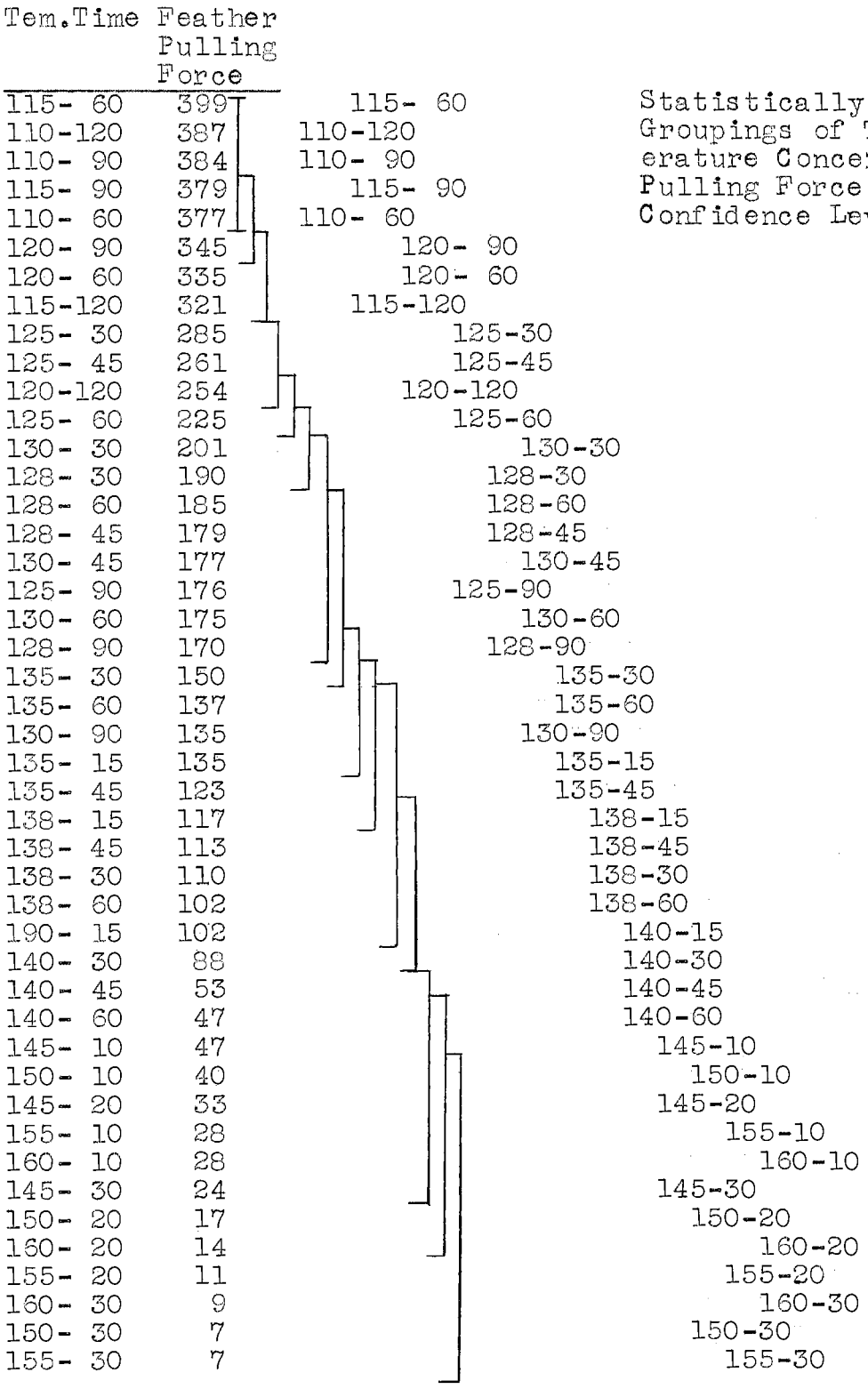

Average Temperature at the base of the Feather for the life broiler and at Selected Time Intervals after Killing
110
109
108
107
106
105
104
103
102
101
100
DEGREES FAHRENHEIT
5
10
15
30
40
MINUTES AFTER KILLING

FIGURE 2.



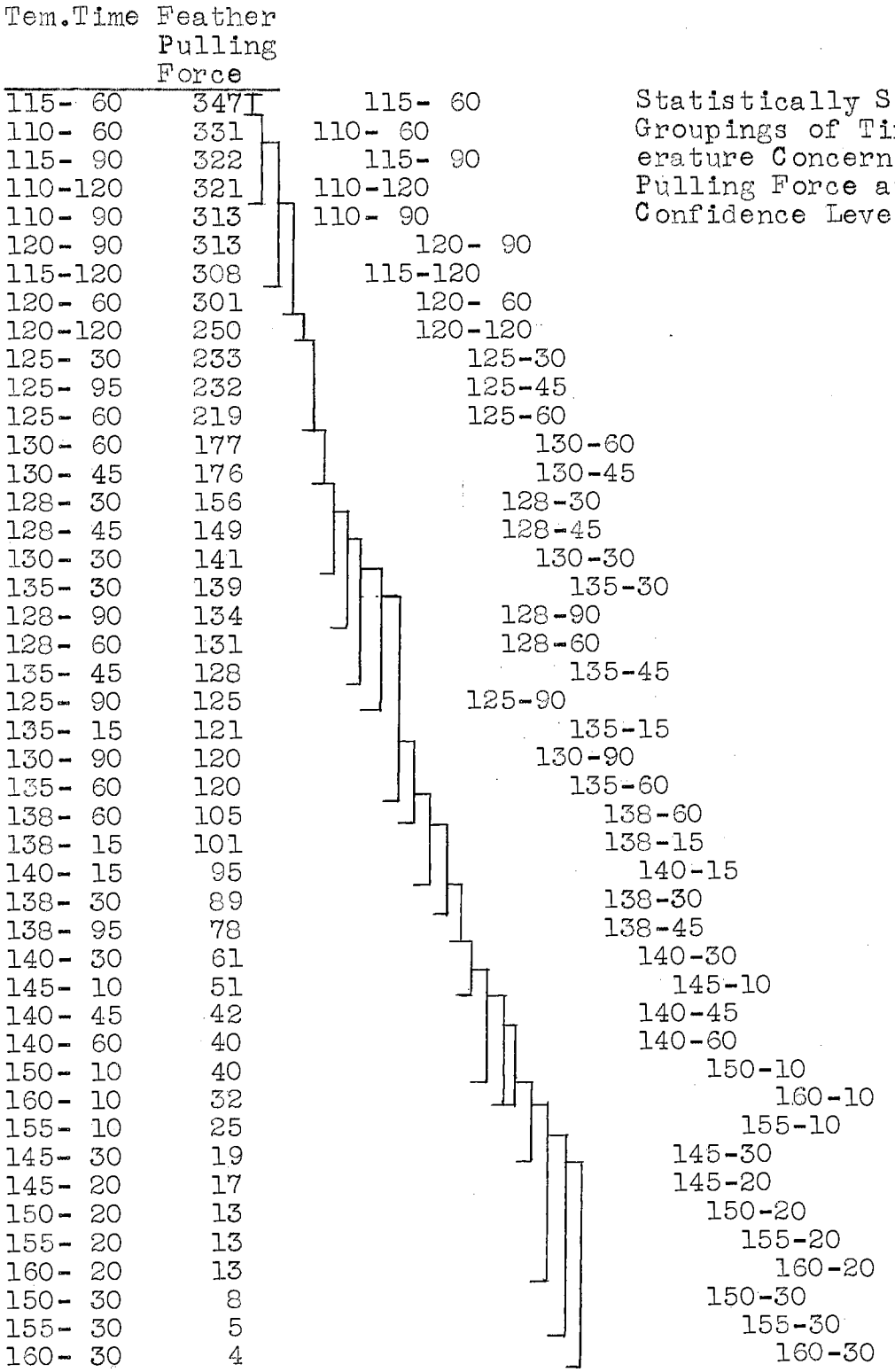
Statistically Significant Groupings of Time and Temperature Concerning Feather Pulling Force at the 95% Confidence Level for Males

FIGURE 3



Statistically Significant Groupings of Time and Temperature Concerning Feather Pulling Force at the 99% Confidence Level for Males

FIGURE 4



Statistically Significant Groupings of Time and Temperature Concerning Feather Pulling Force at the 95% Confidence Level for Females

FIGURE 5

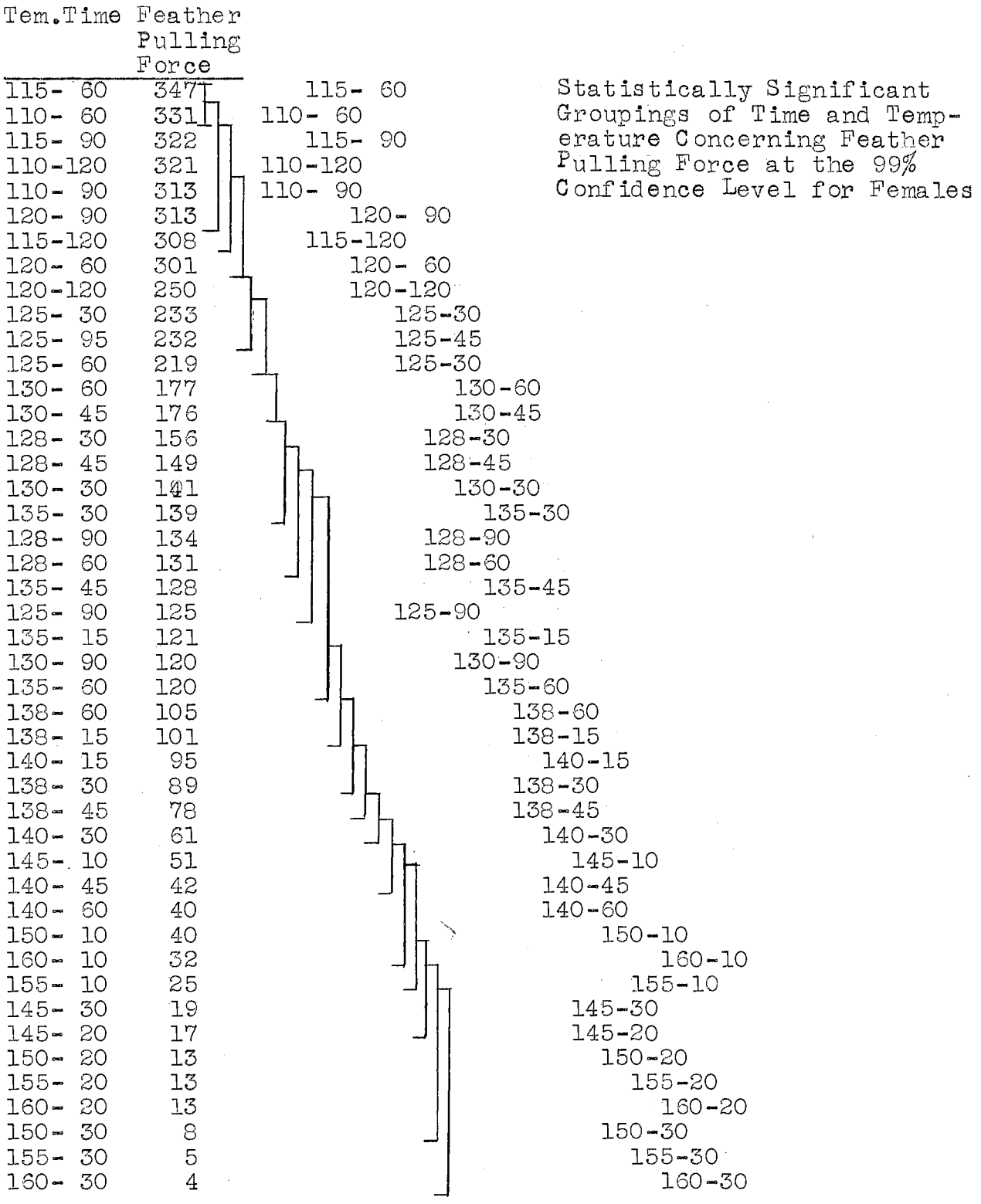

Tem.Time
Feather Pulling Force
115- 60 347
110- 60 331
115- 90 322
110-120 321
110- 90 313
120- 90 313
115-120 308
120- 60 301
120-120 250
125- 30 233
125- 95 232
125- 60 219
130- 60 177
130- 45 176
128- 30 156
128- 45 149
130- 30 141
135- 30 139
128- 90 134
128- 60 131
135- 45 128
125- 90 125
135- 15 121
130- 90 120
135- 60 120
138- 60 105
138- 15 101
140- 15 95
138- 30 89
138- 45 78
140- 30 61
145- 10 51
140- 45 42
140- 60 40
150- 10 40
160- 10 32
155- 10 25
145- 30 19
145- 20 17
150- 20 13
155- 20 13
160- 20 13
150- 30 8
155- 30 5
160- 30 4
115- 60
110- 60
115- 90
110-120
110- 90
120- 90
115-120
120- 60
120-120
125-30
125-45
125-30
130-60
130-45
128-30
128-45
130-30
135-30
128-90
128-60
135-45
125-90
135-15
130-90
135-60
138-60
138-15
140-15
138-30
138-45
140-30
145-10
140-45
140-60
150-10
160-10
155-10
145-30
145-20
150-20
155-20
160-20
150-30
155-30
160-30
Statistically Significant Groupings of Time and Temperature Concerning Feather Pulling Force at the 99% Confidence Level for Females

FIGURE 6

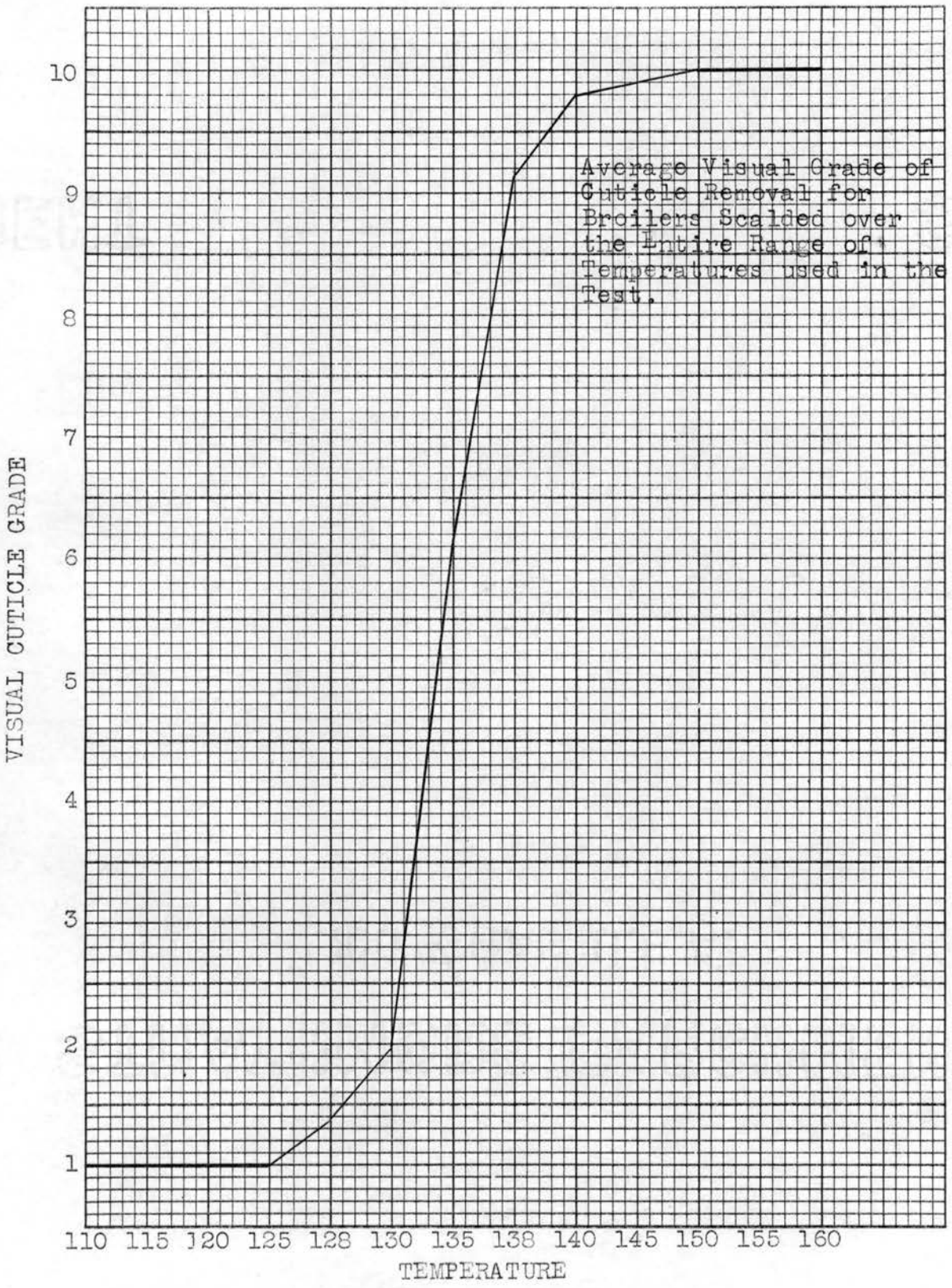

Average Visual Grade of Cuticle Removal for Broilers Scalded over the Entire Range of Temperatures used in the Test.
VISUAL CUTICLE GRADE
10
9
8
7
6
5
4
3
2
1
110 115 120 125 128 130 135 138 140 145 150 155 160
TEMPERATURE

FIGURE 7.

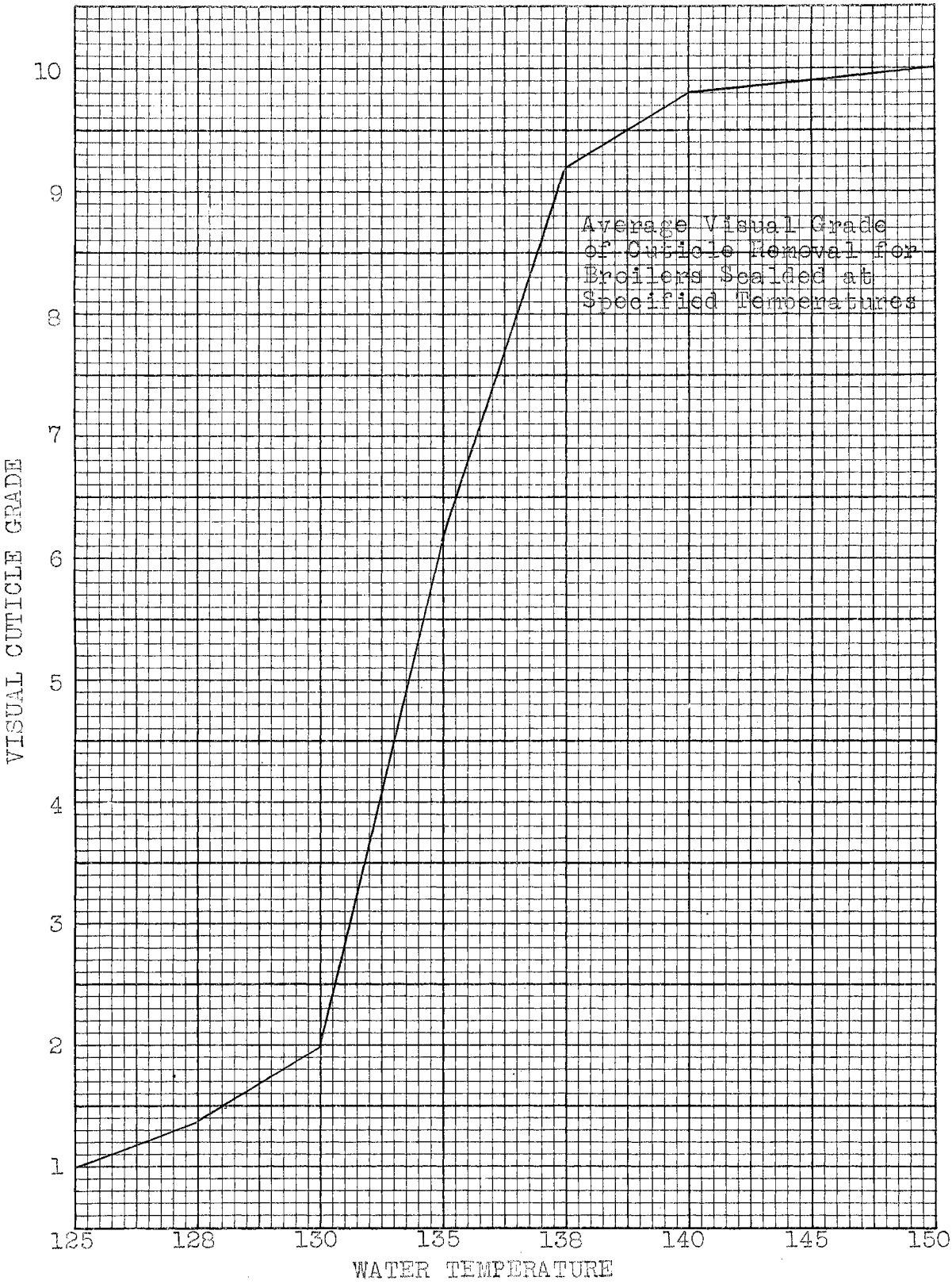

Average Visual Grade of Cuticle Removal for Broilers Scalded at Specified Temperatures
VISUAL CUTICLE GRADE
10
9
8
7
6
5
4
3
2
1
125
128
130
135
138
140
145
150
WATER TEMPERATURE

FIGURE 8.

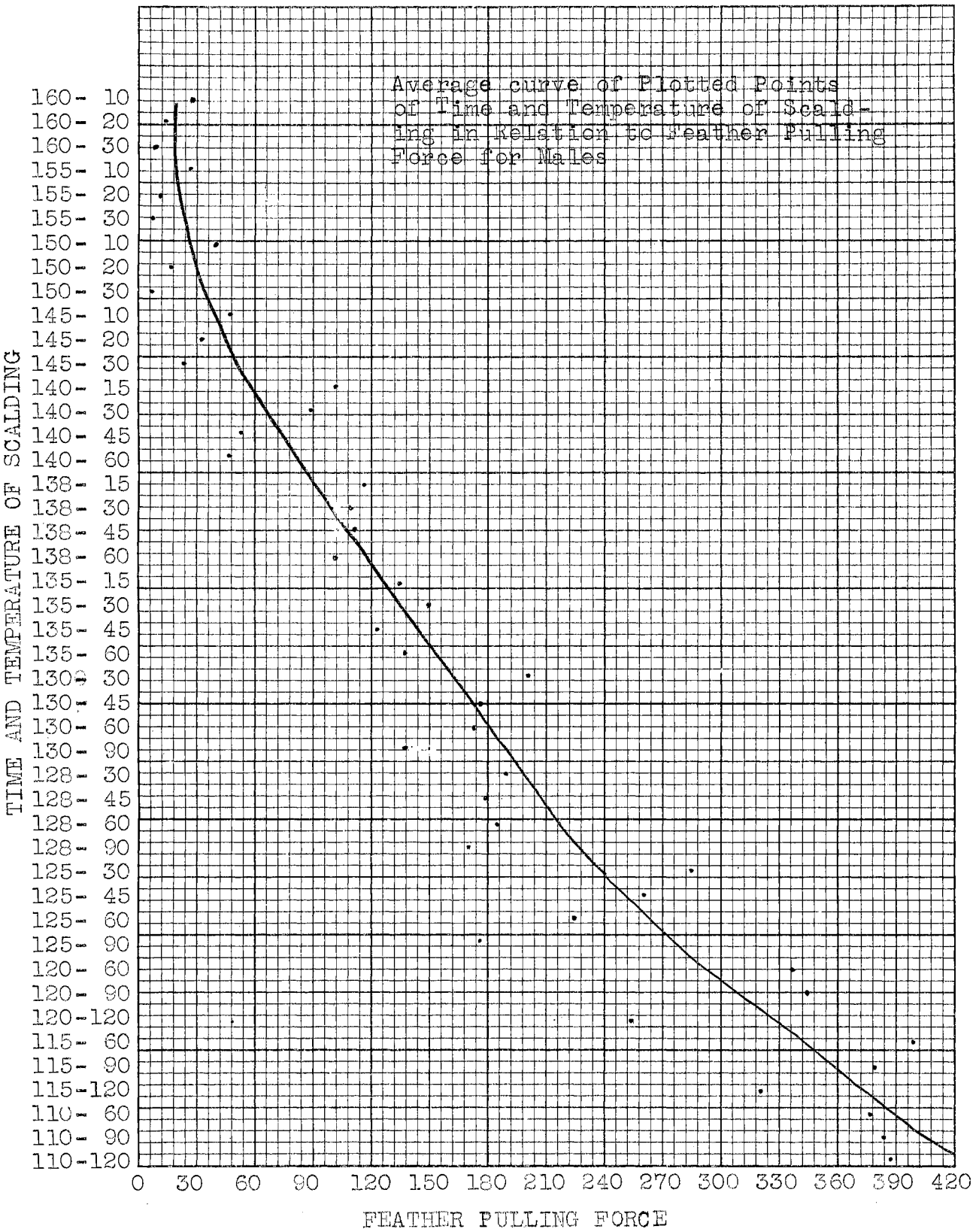

Average curve of Plotted Points of Time and Temperature of Scalding in Relation to Feather Pulling Force for Males
TIME AND TEMPERATURE OF SCALDING
160 - 10
160 - 20
160 - 30
155 - 10
155 - 20
155 - 30
150 - 10
150 - 20
150 - 30
145 - 10
145 - 20
145 - 30
140 - 15
140 - 30
140 - 45
140 - 60
138 - 15
138 - 30
138 - 45
138 - 60
135 - 15
135 - 30
135 - 45
135 - 60
130 - 30
130 - 45
130 - 60
130 - 90
128 - 30
128 - 45
128 - 60
128 - 90
125 - 30
125 - 45
125 - 60
125 - 90
120 - 60
120 - 90
120 - 120
115 - 60
115 - 90
115 - 120
110 - 60
110 - 90
110 - 120
0 30 60 90 120 150 180 210 240 270 300 330 360 390 420
FEATHER PULLING FORCE

FIGURE 9.

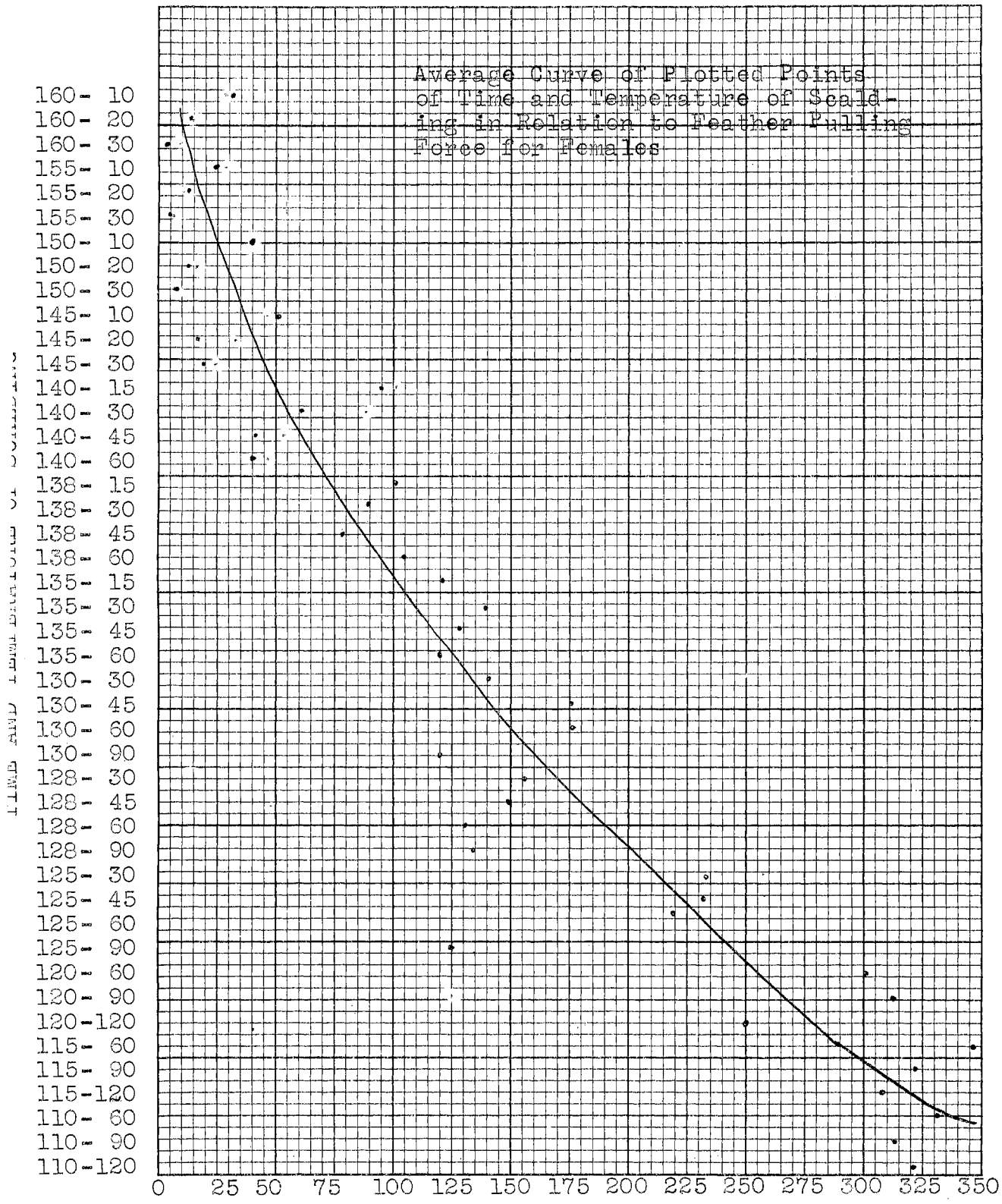

Average Curve of Plotted Points of Time and Temperature of Scalding in Relation to Feather Pulling Force for Females
160 - 10
160 - 20
160 - 30
155 - 10
155 - 20
155 - 30
150 - 10
150 - 20
150 - 30
145 - 10
145 - 20
145 - 30
140 - 15
140 - 30
140 - 45
140 - 60
138 - 15
138 - 30
138 - 45
138 - 60
135 - 15
135 - 30
135 - 45
135 - 60
130 - 30
130 - 45
130 - 60
130 - 90
128 - 30
128 - 45
128 - 60
128 - 90
125 - 30
125 - 45
125 - 60
125 - 90
120 - 60
120 - 90
120 -120
115 - 60
115 - 90
115 -120
110 - 60
110 - 90
110 -120
0 25 50 75 100 125 150 175 200 225 250 275 300 325 350
FEATHER PULLING FORCE

FIGURE 10.

DISCUSSION

Observations of body temperatures of broilers after killing indicates that the body heat is not lost quickly. Normally birds would not be held for the lengths of time as tested in this experiment before being scalded and picked. The loss of body temperature is greater during the first 15 minutes rather than the second 15 minutes after killing. An average total loss of 1.5 degrees F. was recorded at the end of the first 15 minute period after killing. During the next 15 minutes an average loss of 0.14 degrees F. was noted. There was an increase in the rate of temperature loss at 30 to 40 minutes over the preceeding period. An average of 0.26 degrees F. was lost at that time

Rigor mortis had begun to be evident five to ten minutes after the birds had been killed. Birds placed on the mechanical picker after rigor mortis had started in the body were extremely difficult to pick. In most cases the skin of the bird was torn by the picker. The time elapsing after killing and before submerging in the water has little or no effect on feather removal; provided rigor mortis has not taken place. There was no difference in the ease of feather picking or percentage of cuticle removal of birds immersed in the water 30 seconds after killing or five minutes after killing unless rigor mortis had already begun.

The value of one time and temperature scald over another within one group in regard to feather pulling force depends on the cuticle grade. A relative value must be given rather than an absolute value.

With the exception of birds scalded at 120 degrees F. for 120 seconds, those birds scalded at 110, 115, and 120 degrees F. at all time intervals would not pick well on the mechanical picker. Back and wing feathers in particular were not removed at the two lower temperatures and a large number of feathers remained at 120 degrees F. although not as many as at the lower temperatures.

At 125 degrees F. time is an important factor. Those birds scalded for 90 seconds picked fairly easily, produced a good looking carcass, and had few pin feathers. Those birds scalded for 60, 45, and 30 seconds had many more pin feathers. Wing feathers remained after picking on those birds scalded for 30 seconds.

Birds scalded at 128 degrees F. for 45 and 30 seconds were for the most part pin free while those scalded for 90 and 60 seconds were completely pin free. At temperatures of 130, 135, and 138 degrees F. feathers were easily removed. No feathers or pin feathers remained at each time of scalding.

Temperatures at 140 degrees F. and above are too high for scalding regardless of the scalding times used. Feather removal is undoubtedly easy at those temperatures but the

cuticle in practically all cases was completely removed. After being hung for two hours in the cooler, discoloration and blistered burns on the carcass were in evidence.

The feather pulling force was more varied at the different times of scalding at the very high temperatures than at the lower temperatures. At the lower temperatures, 110 to 120 degrees F., the length of time of scalding was not as important a factor as temperature in determining feather pulling force. At 110 degrees F. the feather pulling force was approximately the same at all three scalding times. At 150 degrees F. and above the feather pulling force was clearly defined at each time scald.

Variation between individual birds was of considerable importance in this experiment. This was also mentioned by Pool (1955). For example, one female scalded at 135 degrees F. for 15 seconds had an average feather pulling force of 67 grams while another scalded at 145 degrees F. for 30 seconds had an average feather pulling force of 104 grams. The former was far below the average for that particular class and the latter above the average for her class.

Males on the average had a greater feather pulling force than did females. At seven out of 45 time and temperature scalds females averaged a higher feather pulling force than males but the greatest difference was only 5 grams. This occurred at scalds of 130 degrees F. for 60 seconds, 135 degrees F. for 45 seconds, 138 degrees F. for 60 seconds,

145 degrees F. for 10 seconds, 150 degrees F. for 30 seconds, 155 degrees F. for 20 seconds, and 160 degrees F. for 10 seconds.

No cuticle was removed at temperatures of 110, 115, 120, and 125 degrees F. at each of the specified scalding times. Small amounts of cuticle were removed from broilers scalded at 128 degrees F. for 90 and 60 seconds. Birds scalded for 45 and 30 seconds resulted in top quality carcasses with no cuticle lost after picking. At temperatures of 130 degrees F. about ten per cent of the cuticle was removed at all scalding times.

Time was an important factor in cuticle removal at 135 degrees F. Grades of 8.2 and 8.4 were recorded for scalds of 60 and 45 seconds. The average grade went down as the length of scald decreased. Grades of 5.2 and 2.8 were seen at 30 and 15 seconds. Scalds at 138 degrees F. for 60 and 45 seconds removed the entire cuticle after picking. A small portion of the cuticle, approximately 10 per cent, was left on the birds at 30 seconds. Scattered portions of cuticle along the back were not removed at 15 seconds and an average grade of 7.5 was noted.

Scalds at 140 degrees F. removed the entire cuticle at times of 60 and 45 seconds. Only on a few birds did any cuticle remain when scalded for 30 and 15 seconds. A grade of 9.6 was recorded for birds scalded at 145 degrees F. for 10 seconds but no cuticle remained at scalds of 30 and 20

seconds. Temperatures of 150 degrees F. and above removed the cuticle completely at all times.

The best time and temperature scald of the entire experiment was the one which averaged the lowest feather pulling force and resulted in a cuticle grade of 1. Birds scalded at 125 degrees F. for 90 seconds and those scalded at 128 degrees F. for 45 seconds had the lowest feather pulling force of birds classified as grade 1. The average feather pulling force at 125 degrees F. for 90 seconds was 176 grams for males and 125 grams for females. This compared favorably with birds scalded at 128 degrees F. for 45 seconds whose feather pulling force was 170 grams for males and 149 grams for females.

SUMMARY AND CONCLUSIONS

The rate of loss of body temperature of broilers, effect of time and temperature in scalding for different lengths of time, and cuticle removal at different times and temperatures were studied. From this study of 236 male and 235 female New Hampshire broilers the following conclusions may be drawn:

1. Loss of body heat from broilers immediately after killing does not drop quickly.

2. Rigor mortis in broilers takes place approximately five to ten minutes after killing.

3. The force to pull feathers from males is greater than females.

4. Temperature is a more determining factor than time in the removal of feathers from broilers.

5. The force required to remove feathers from broilers is directly related to time and temperature.

6. There is a great deal of individual bird variation in feather pulling force at like times and temperatures.

7. The amount of cuticle remaining on the carcass decreases as the scalding water temperature increases above 128 degrees F.

8. Birds scalded at temperatures of 140 degrees F. and above, in almost all instances, will result in the entire cuticle being removed at any of the specified times of scalding.

9. In regard to the combined results of feather pulling force and cuticle grade the best time and temperature scalds are 125 degrees F. and for 90 seconds and 128 degrees F. for 45 seconds for New Hampshire broilers.

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VITA

Bernard Nassau
candidate for the degree of
Master of Science

Thesis: THE RELATIONSHIP OF TIME AND TEMPERATURE IN THE REMOVAL OF FEATHERS DURING THE PROCESSING OF BROILERS

Major: Poultry Marketing

Biographical:

Born: January 16, 1930 at New York City, N. Y., son of Mr. and Mrs. Philip Nassau

Undergraduate Study: Oklahoma A & M College, 1948-1952

Graduate Study: Oklahoma A & M College, 1954-1955

Experiences: Army, 14th Engineer Combat Battalion in Korea 1953-1954.

Former President of Spur and Comb Club, Member Aggie Council.

Date of Final Examination: June, 1955

THESIS TITLE: THE RELATIONSHIP OF TIME AND TEMPERATURE IN THE REMOVAL OF FEATHERS DURING THE PROCESSING OF BROILERS

AUTHOR: Bernard Nassau

THESIS ADVISER: George W. Newell

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TYPIST: Sara Preston