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Factors Affecting Poultry Meat Yields

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FOREWORD

The first regional publication with this title was NC Regional Publication No. 158 published in 1964. The first version covered published material on poultry meat yields from 1950 to 1964. The present updated publication covers the last ten years (since 1964) in this rapidly changing field.

NCM-46 is an example of regional research committees as they should function. Research people from ten North Central region experiment stations, seven experiment stations from other regions, and four separate USDA units are actively involved in the planning and execution of the project objectives. This allows for excellent input and discussion at the annual meeting and results in publications of this type.

A significant part of the research making up this publication resulted from research under the direction of members of NCM-46. In addition, the training of graduate students is important, in order to provide a continued supply of professionals for future poultry products research.

With the rapidly changing scene related to food supply and nutritional needs of our population, there is a need for research in the important area of poultry products technology as related to total food supply. Continued research on the many problems related to poultry products by the NCM-46 regional committee appears to be a sound approach.

Over the life of the NCM-46 Committee, the contributing researchers have been extremely productive in cooperatively arriving at scientific answers to many problems important to the poultry industry. The past record should justify continued support of this important research area.

Factors Affecting Poultry Meat Yields

C. W. Carlson, W. W. Marion, B. F. Miller and T. L. Goodwin[1]

It has been 10 years since the previous publication[2] bearing this title was issued. A quote from that publication, ". . . research reported 10 or more years ago is of questionable value because of the rapid progress made by the poultry indusry . . ", indicates that an updated review is now necessary. Information in that publication is not repated here. The earlier report is still of much value, especially as it pertains to methodology and guidelines for comparing yield data.

Although many of the same frustrations persist, in that "all conditons of the research reported are not spelled out in the original articles and in many cases insufficient numbers were used to apply the results to commercial conditions," yet the authors here quoted are, in great measure, to be commended for progress in this regard. The NCM-46 Regional Technical Committee surveyed the literature available on the subject; the number of papers originated by members of the commitee represents a major proportion of the reports reviewed.

GENETICS

Chickens:

Dressing percentage of broilers is a trait influenced by selection. Muir and Goodman (1964) showed that a selected line had 0.62% greater dressing yield ($P<0.05$) after three generations than a random-bred line. Expected gain in dressing yield was 0.65%. The heritability of additive genetic effects was 0.14%, of nonadditive effects, 0.37%. Progress in this field is slow, but since market value of broilers is influenced by eviscerated yield the technique is important to consider. In a later report, Goodman and Muir (1965) showed that comb type had no effect on dressing percentage. However, broilers possessing walnut type combs were most uniform in percentage yield. Rapid feathering (sex-linked) was related to more uniform carcasses but had no effect on dressing percentage.

Broiler strains containing some Cornish breeding still rank high in eviscerated yield, as reported in the previous bulletin (Swanson et al., 1964). Moran et al. (1970a) showed that not only was the Cornish × White Rock cross superior in growth but also showed the smallest eviscerating loss compared to the purebreds and the reciprocal cross. However, Moran and Orr (1970) showed that commercial broiler strains of these breeds and their crosses were similar in yield of breast meat, thigh or drumstick, providing only Grade A carcasses were evaluated. Crosses involving line B (breed not idenitified) produced larger male progeny that showed an apparent yield of 68.5% compared to 67.6 and 67.9% for the crosses with line A. Females yielded 30.9 to 31.2% breast meat compared with 29.5 to 30.5% for males, confirming data from the earlier report (Swanson et al., 1964). As before, males compensated with a greater yield of drumsticks, 16.1 to 16.4% vs. 14.9 to 15.2% for females.

Hayse and Marion (1973) reported on the yield of component parts of broilers and indicated that their values for breast meat were somewhat higher than had been reported in the 1950's. However their values were lower than those reported by Moran and Orr (1970). A compilation of their data is shown in Table 1.

Similar results were reported by Bouwkamp et al. (1973) for sex differences. Breast yields of males were

Table 1. Percentage yield of cut-up parts of chilled ready-to-cook male and female broilers at 8 weeks of age.*

Part	Sex	Yield (% of carcass)
Total†	Male	72.0
	Female	70.1
Breast	Male	26.6
	Female	28.3
Thigh	Male	17.5
	Female	17.2
Drumsticks	Male	16.3
	Female	15.5
Wings	Male	11.7
	Female	12.1
Neck	Male	3.8
	Female	3.5
Tail rack	Male	9.6
	Female	9.4
Rib rack	Male	8.9
	Female	8.4
Heart	Male	0.56
	Female	0.55
Liver	Male	2.6
	Female	2.4
Gizzard	Male	2.6
	Female	2.7

*From Hayse and Marion (1973).
†Ratio of chilled (w/o water contact) eviscerated wt. to live wt., males =1841 g., females=1494 g.

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[2]Bulletin 476, University of Minnesota, 1964.

significantly smaller than that of females. They found that a Hubbard × Arbor Acre (HA) cross showed a greater yield of breast and back but a smaller yield of wings and drumsticks than a Vantress × Arbor Acre (VA) cross. If gross weight differences were eliminated, the differences were less marked. In the 1,200 to 1,300 gram group, the VA cross still had a greater drumstick yield. In the 1,100 to 1,200 gram group the HA cross had less proportion of wings and a larger proportion of backs.

Turkeys:

In making comparisons of cooked weight with frozen weight, Mostert et al. (1966) showed significant differences between strains. Two strains averaged 74.6% yield, whereas three other strains showed a 73.1% yield.

MacNeil and Buss (1968) reported that feather color did not relate to meat yield of large type turkeys; however, extensive variation in meat yield occurred between unrelated Bronze and White varieties or between strains or either variety. Bronze turkeys yielded less total skin, more breast meat and larger wings compared to an unrelated White variety (6.0 to 8.9%, 34.0 to 31.5% and 13.0 to 12.2%, respectively). Even between Bronze strains entered in the Pennysłvania Turkey Random Sample Meat Test in 1964, variation in breast meat yields ran from 32.6 to 37.4%, while total skin varied from 9.6 to 5.8% in adverse relationship. Two Small White strains yielded 11.0 and 12.4% total skin, respectively. The spongy mass of neck skin of all strains varied from 2.4 to 6.3% of the dressed carcasses.

When the neck skin data from males of six strains of turkeys from the Pennsylvania tests were arranged in ascending order from 1.7 to 4.9%, total skin ranged from 5.1, to 10.4%, being directly proportional (MacNeil 1969). At the same time breast meat yield data ranged from 39.9 to 31.9% in generally inverse order to skin percentage. Data for the females tended to follow the same trends with the ranges being from 1.5 to 3.4%, 5.4 to 10.3% and 38.9 to 27.9%, respectively. He reported that five bird samples were adequate for obtaining meat yield data, whereas more birds were desirable for skin data. Eviscerated weight was found to be the best indicator of meat yielding capacity and breast width a reliable indicator of breast meat yield. Marion et al., (1970) reported breast and skin yield data of 25.7 and 9.7% for one strain and 27.5 and 8.8% for another, confirming MacNeil's observation that the two are inversely related. In the work of Hartung and Froning (1968), strain or variety had no effect on meat yield other than that the smaller birds showed lower meat yields.

Dobson (1969) reported on the meat yields of 31 strains of turkeys. Breast meat yields varied from 29.0 to 34.5% while total meat yields varied from 68.1 to 72.9% in the same order for the various strains. Data for dark meat showed less variation, 25.9 to 27.0% with little relationship to total yield. He also found skin percentages to be inversely related to breast meat yield and total meat yield. For this data, size was not always a factor influencing meat yield. One strain was nearly the largest in size and eviscerated weight but was next to last in percentage total meat yield.

Hayes and Moreng (1973) evaluated seven strains of Large White toms on the basis of body weight, slaughter weight, carcass weight, total meat weight and breast and thigh meat weight and value. They found one strain to be superior in all categories. None of the other strains compared favorably with the superior strain.

SIZE AND AGE

As stated before (Swanson et al., 1964), "Research data on meat yields usually confirm the general principle that within a particular class of poultry the heavier the bird, the larger the yield on a percentage basis." Data have not been reported to completely refute this observation. The data of Dobson (1969) for turkeys reported above are not in conflict when one divides the strains into two groups, those below 23 pounds eviscerated weight and those 23 pounds or larger. The data reported were for the average of five slaughter ages, i.e. 22, 24, 26, 28 and 31 weeks. With males now going to market mainly at 22 to 24 weeks of age, the data were somewhat weighted toward more mature types.

Chickens:

The data of Moran and Orr (1969) substantiate the above regarding relationship of weight and yield. When broilers were eviscerated at 6, 8 and 10 weeks of age, dressing losses decreased for males and females from 12.6 to 11.0% and 13.7 to 12.1%, respectively. Similarly, eviscerated losses dropped from 24.3 to 21.7% and 26.0 to 20.5%, respectively. Back skin fat showed no changes in this time period, but total carcass fat increases were shown.

Jacobson et al. (1969) reported lean meat yields, from broilers processed at five ages as shown in Table 2. Analysis of the data showed no significant increase after 9 weeks of age. It was evident from this study, however, that to obtain superior meat yield, broilers should not be slaughtered before 9 weeks of age.

Table 2. Lean meat yields of broilers as affected by age and cooking method.*

Sex-Cooking Method	Weeks of Age 5	7	9	11	13
	%	%	%	%	%
Males					
Roasted	36.5	38.2	39.8	40.3	40.0
Fried	36.0	36.0	39.0	38.2	39.3
Females					
Roasted	37.5	37.2	39.4	40.0	40.3
Fried	34.2	36.1	37.8	37.0	38.7

*From Jacobson et al. (1969).

Cooked meat yields from roasters, and heavy and light hens, were determined by Minor et al. (1964). Roasters yielded the highest percent cooked lean meat (36.6%), light hens next (35.5%) and heavy hens the least (33.5%). Yield of total edible product (lean, fat and skin) was likewise highest for roasters (52.7%) followed by the heavy hens (49.8%), and the light hens yielded the least (47.7%). Light hens had the highest percent bone, heavy hens yielded the highest percent total lipid. Light hens produced a higher percent cooked breast meat; roasters had the highest percentage cooked leg meat. Heavy hens yielded more breast meat than roasters, but less than the Leghorn fowl.

Turkeys:

Dobson (1969) has reported extensive data on effects of age on meat yields in turkeys. The data for each value in Table 3 is for an average of about 400 turkeys.

Maximum yield of total meat showed little change to 28 weeks. At that point or by 31 weeks of age less total meat yield resulted. It would appear that for yield alone, turkeys should not be grown beyond 28 weeks of age. The potential yield of breast meat causes further processors to encourage producers to hold their birds to 28 weeks of age if at all possible. Greater yield per unit of time is also obtained with the larger birds. Premium pricing for the older birds may be necessary to justify retaining them to that age.

Hartung and Froning (1968) reported that total meat yield increased from 18 to 26 weeks of age for toms but did not show such a trend for hens (Table 4). The most dramatic change for the toms came at the 26-week period, coinciding with the greatest decrease in bone yield. Proportion of skin showed a rather steady increase with either sex, and bone yield of hens decreased to 22 weeks of age. The Hartung-Froning work indicates that, for maximum yield of edible product with the least amount of skin and bone, toms should be slaughtered at 26 weeks of age, hens at 18 weeks of age.

In the work reported by Mostert et al. (1966) age was also an important factor in yield of product as cooked from the frozen state. The yield data for turkeys 12, 18 and 24 weeks of age were 77.1, 73.2 and 70.7%, respectively, even though less time was required per unit of weight to cook the carcasses of the older birds. Size per se was not an important factor in this work in that a Small White and a Large White strain were similar and differed from two other Large White strains and a Bronze strain.

Miller (1968) reported yield data for increasing sizes of tom turkey carcasses obtained from commercial sources (Table 5). As might be expected from Dobson's work with various ages, the larger carcasses up to 11.8 kg. showed greater yields. However, the still heavier carcasses showed reduced yield. As indicated by the greater skin yield, this was probably because of the greater fat content of the carcass. Comparative market values of different parts of the carcass were calculated on the basis of meat yield only. Considering the whole carcass to be equal to 100, breast and thighs (with bone) would have a value of 130, drumsticks 100, first section of wing 83, second section 70, whole wing 70 and turkey meat per se 167 (see Table 6 for a comparison at various prices).

Moran et al. (1970) and Moran et al. (1971) reported on yields from raw and cooked Large White and Small White turkeys, respectively, as influenced by age. As shown in Table 7, yields of cooked product increased with age. They also reported detailed data on yields of various raw chilled and cooked parts, carcass chemical analyses, grading data for conformation, fleshing and breast and back finish, total weights and feed efficiency. Their conclusions for maximum returns in feed efficiency and yield of product were that the Large White type should be marketed at 23 and 21 weeks for toms and hens, respectively. In similar manner, the Small White should be marketed at 16 and 15 weeks of age, respectively. The differences between the sexes were much less pronounced for the Small White type. The Large White type showed marked differences,

Table 3. Influence of age of male turkeys on raw carcass percentages.*

Age Weeks	Wing %	Breast Meat %	Thigh Meat %	Drum-stick %	Bone %	Skin %
22	13.0	29.3	13.7	13.8	21.3	6.4
24	12.8	30.3	13.4	13.2	21.2	6.8
26	11.9	31.2	13.4	13.0	20.0	7.8
28	11.7	32.2	13.3	12.5	19.7	8.6
31	10.4	32.4	13.0	12.0	18.5	11.5

*Adapted from Dobson (1969).

Table 4. Meat, skin and bone yield of uncooked turkeys as influenced by age.*

Age Weeks	Meat Toms %	Meat Hens %	Skin Toms %	Skin Hens %	Bone Toms %	Bone Hens %
14	----	61.3	----	7.5	----	31.2
16	----	60.5	----	8.0	----	31.5
18	61.2	62.8	6.5	8.0	32.3	29.2
20	62.0	62.5	7.5	9.6	30.5	27.9
22	61.8	62.3	8.8	11.5	29.4	26.2
24	62.9	60.8	10.1	12.5	27.0	26.7
26	66.4	----	11.0	----	22.6	----
28	66.1	----	12.3	----	21.6	----

*Adapted from Hartung and Froning (1968).

Table 5. Meat, bone and skin yield (%) from raw carcasses as influenced by carcass size.*

Carcass Wt., kg.	Meat	Breast	Thigh	Bone	Skin
6.5- 7.3	59.3	26.9	14.0	31.1	7.5
7.5- 8.8	62.0	28.0	14.2	29.4	7.8
10.8-11.8	63.4	31.8	12.5	22.6	11.2
13.0-14.4	60.8	29.5	13.2	25.0	11.9

*Adapted from Miller (1968).

Table 6. Value of different turkey parts compared to the whole carcass based on meat yield only.[1]

Price of whole turkey (cents)	Comparative price of: Drum-sticks	Wings Section 1	Wings Section 2*	Breasts and thighs†
29	29	24.0	20.3	37.7
31	31	25.6	21.7	40.3
33	33	27.3	23.1	42.9
35	35	28.9	24.5	45.5
37	37	30.6	25.9	48.1
39	39	32.2	27.3	50.7
41	41	33.9	28.7	53.3
43	43	35.5	30.1	55.9
45	45	37.2	31.5	58.5
47	47	38.8	32.9	61.1
49	49	40.5	34.3	63.7
51	51	42.1	35.7	66.3
53	53	43.8	37.1	68.9
55	55	45.4	38.5	71.5
57	57	47.1	39.9	74.1
59	59	48.7	41.3	76.7

*Section 2 of the wing yielded the same percentage of meat as whole wings.
†Breasts and thighs yielded about the same percentage of meat.
[1]From Miller (1968).

especially regarding the poorer back finish of toms and a larger proportion of skin associated with the cooked carcass of the hen.

EFFECT OF NUTRITION

In general, unless dietary differences alter the rate of growth ,there is a minimal effect of nutrition on edible carcass yield. Small differences in growth usually do not alter carcass yield. Perhaps for this reason yield data are most often not obtained in nutrition experiments. The few available results to be presented here largely substantiate these statements.

FATS OR ENERGY LEVEL

Chickens:

Quarles et al. (1968) varied the amounts of hydrolyzed animal and vegetable fats from 0 to 6% of the diet and reported these effects on the growth and carcass characteristics of broilers. The fats were added to the starter and finisher rations which contained 23 and 21% protein and 2,820 and 2,970 M.E. Cal./kg., respectively. Although yield data are not given, each increment of fat improved growth but had no consistent or real effect upon skin fat. In fact, the birds on 4 or 6% fat showed lower skin fat than those on 0 or 2% fat levels. On this basis, yield would not be expected to differ. However, there was a highly signficant increase in incidence of breast blisters with each fat increment. As a result, reduced yields would be expected. Incidentally, each increment of the added fat reduced shear force values of meat and therefore improved tenderness.

Ten percent fat from one of three sources—corn oil, lard hydrogenated coconut oil—showed growth responses with broilers housed at 21° C. or 29° C., in work reported by Mickelberry et al. (1966). Fats replaced glucose in a corn-soybean meal diet and caused a 10 to 15% improved feed conversion. Carcass yield data again are lacking, but composition data showed the fats reduced moisture content and increased fat content, especially of skin and abdominal fatty tissue. Iodine number determinations of carcass lipids reflected the degree of saturation of the dietary fatty acids. Lard produced the greatest changes in carcass lipids but less change in iodine number compared with the control and other fat treatments. One might expect the yields to have been reduced by the fat treatments.

Turkeys:

Low, moderate and high energy finishing diets were fed to Large White hens and toms from 18 to 21 or 23 weeks of age, respectively, by Moran et al. (1969). Cellulose was replaced by 14% glucose or 25% glucose and 1.25% tallow in obtaining the moderate and high energy diets, respectively. Although energy differences for the developing period, 8 to 18 weeks, were also included in the study, their effects on the final performace data were minimal and so the data were combined for the summary shown in Table 8. In this work, energy differences for the finisher diets had a marked influence on growth, which in itself may have affected the increase in carcass yield noted for both toms and hens. Although specific gravity was not markedly altered, the larger carcasses contained greater quantities of skin fat which must have contributed to the greater carcass yield.

Diets of equal calorie:protein ratios containing 0, 2 and 11.4% palm oil or rapeseed oil were fed to male turkeys to 24 weeks of age and the work reported by Salmon and O'Neil (1971). Palm oil stimulated growth, whereas the rapeseed oil depressed growth. The additions of fat at the 2% level had more effect on the carcass than the further increase of fat to 11.4%. Increased yield of skin, increased fat content of breast and thigh and greater drip losses in cooking were noted from the fat-fed groups. The additions of fat also decreased the meat yields from breast, thigh and drumstick and decreased the volatile cooking losses.

ENERGY and/or PROTEIN or AMINO ACID LEVELS

Chickens:

No effects upon eviscerated yield of chickens were observed by Essary et al. (1965) when increasing, constant, or decreasing calorie:protein ratios were maintained by the addition of 2, 4, 6 and 8% of fat. With the

Table 7. Meat, bone and skin yield (%) of cooked turkey carcasses as influenced by age and type*

Age Weeks	Meat	Breast	Thigh	Bone	Skin
		Toms—Large White			
17	65.6	28.0	12.5	23.3	8.8
19	68.9	29.2	13.1	21.1	8.2
21	68.4	30.0	13.1	19.5	9.8
22	68.9	30.8	13.1	19.0	10.7
23	70.7	31.7	13.5	16.9	10.3
25	71.6	32.4	13.5	15.5	11.1
27	72.7	34.0	12.9	15.1	10.5
		Toms—Small White			
12	66.5	28.7	12.5	23.2	8.5
13	66.8	27.6	13.3	23.1	7.4
14	67.3	28.0	13.2	21.8	8.8
15	66.7	27.3	13.0	21.3	9.8
16	67.1	27.9	13.1	20.6	10.3
17	67.5	28.4	13.0	20.7	10.0
		Hens—Large White			
14	67.1	26.9	13.1	23.1	8.8
16	68.2	28.2	13.6	21.0	9.6
17	68.6	29.3	13.3	19.6	10.2
18	68.6	29.1	13.3	19.5	10.6
19	66.6	28.9	12.7	17.8	13.5
21	67.8	30.2	12.9	16.7	13.5
24	69.5	32.4	12.7	15.3	13.3
		Hens—Small White			
10	64.1	25.7	12.3	24.6	9.3
11	66.2	26.4	12.5	23.3	9.3
12	67.0	27.5	12.9	21.8	8.7
13	68.9	28.0	13.3	20.7	9.4
14	69.5	29.2	13.1	18.9	10.4
15	68.9	28.6	13.5	18.6	10.4

*Adapted from Moran et al. (1970b) and Moran et al. (1971).

Table 8. Effect of energy content of finishing diet on growth, carcass yield and skin fat of Large White Turkeys.*

Energy Level	Market Weight	Carcass Yield	Specific Gravity	Skin Fat
	kg.	%		%
Toms				
Low	10.8	70.6	1.044	81.2
Moderate	11.8	73.6	1.045	83.7
High	12.2	73.3	1.044	84.4
Hens				
Low	7.3	70.6	1.045	89.7
Moderate	7.4	71.4	1.044	89.6
High	7.7	71.7	1.042	91.2

*Adapted from Moran et al. (1969).

increasing ratios, growth was increased, but the yield was not significantly increased. In this same series, the carcass specific gravity was reduced by the added fat, suggesting increased fat deposition.

With a suboptimal protein level of 16%, Marion and Woodruff (1966) showed an increased yield with 5% additions of fat, particularly of menhaden oil and beef tallow. Growth rate of the male broilers, however, was not affected. With a more adequate protein level (24%), the fats did increase growth but had no effect upon dressed carcass yield. Lipid content of the meat was increased by the additions of fat and reduced by the higher protein levels, as would be expected.

Where growth was greatly improved by increasing energy levels, Moran (1971) showed increased carcass yields. Where alterations of protein and/or energy did not influence growth, no differences were observed in carcass yield. Submarginal levels of methionine or lysine did not affect carcass yield.

Turkeys:

No significant effects upon carcass yield were noted with 4% corn oil and/or 0.1% lysine additions to a series of low protein diets for Large White turkeys (Carlson et al. 1969). The most striking observation was the 25% increase in linoleic content of carcass fat when corn oil was added to the diet. Subsequent studies by Carlson and Guenthner (1970) involved comparisons of low and normal protein diets for turkeys under a variety of conditions. Growth was reduced about 5 to 7% with the low protein series of diets, whereas carcass yield was reduced only by an average of 1%. Copper at 120 ppm increased growth and dressing yields to a greater extent with turkeys on low protein diets than on normal protein diets (Carlson et al., 1972).

HORMONES OR DRUGS

Diethylstilbestrol in the feed or in pellets is not permitted, nor is estradiol 17-monopalmitate (EMP) or dienstrol diacetate, all widely used in the past for this purpose. A number of reports have appeared since the last review (1964) on the use of EMP. Carcass yield increases of 1 to 2% were reported for chicken roasters by Wesley et al. (1965), Mickelberry (1968), Megally et al. (1969), and York and Mitchell (1969). Growth responses in general were also obtained from EMP. No improvement in yields were reported for EMP with turkeys by Pickett et al. (1968a, 1968b).

Although the potential for continued use of antibiotics in poultry feeds as an aid to growth may be restricted, none of the drugs listed in the Federal Register are reputed to improve dressing yield per se. Many stimulate growth, and on that basis the larger animal should show greater yields. No significant growth responses in turkeys from adding bacitracin to the feed were observed by Carlson and Guenthner (1970), and the effects on carcass yield were not consistent. Definitive studies on this point are lacking.

PRESLAUGHTER FACTORS

Certain preslaughter conditions affect carcass yields. These include hauling and/or holding poultry prior to slaughter, holding conditions and temperature. Part or all of these factors are important in affecting muscle biochemistry and post mortem characteristics of meat.

Holding Time:

Fasting time in excess of 16 hours caused a significant loss in dressed weight of broiler (Smidt et al., 1964). Wabeck (1972) showed that feed withdrawal for 8 to 10 hours is necessary to minimize the amount of feed material remaining in the intestine after slaughter and thus lessen the potential of fecal contamination of the carcasses. A marked loss in dressing yield occurred after 12 hours of fasting; therefore it is important that poultry not be held unduly long before processing.

Poultry occasionally may be hauled extensive distances for processing, and may be held overnight on trucks to conform to the plant's schedule. Such long holding periods generally are detrimental to body weight and grade and, in the summertime particularly, may contribute to death losses. The actual influence on carcass yield appears to be less obvious. King (1950) examined the influence of hauling distance by placing birds in crates—12 birds to a crate—and handling in one of the following ways:

(a) placed on the ground outside the poultry house without feed or water,

(b) transported 300 miles on a platform truck with a small quantity of corn placed in the crates at the start of the trip, or

(c) transported the 300 miles on the same truck with the birds having no access to feed. The weather at the time of this experiment was sunny and clear with a high temperature of 30°C and a low relative humidity. The data in Table 9 show that the birds retained in crates but not hauled had the lowest shrinkage, and that added corn during shipment tended to minimize shrinkage.

Marion et al. (1970) reported that turkeys hauled in a conventional turkey truck for a distance of 90 miles had an average weight loss of 1.24%, with the percentages varying from 0.71 to 1.49 (Table 10). Holding one-half of the turkeys at the plant for an additional 24 hours resulted in just over 4% additional shrink.

Temperature:

The same workers (1970) studied the influence of preslaughter environmental temperature on eviscerated yield of adult, Large White turkey males. Sixty turkeys were weighed individually, placed four per coop and randomly assigned to one of three environmental cham-

Table 9. Shrinkage in birds 14 weeks of age after being shipped 300 miles by truck.*

Handling Method†	Males Initial Weight	Males Shrinkage	Females Initial Weight	Females Shrinkage
	(kg)	(%)	(kg)	(%)
a	2.12	6.74	1.62	6.06
b	2.15	7.20	1.62	6.85
c	2.16	7.74	1.63	7.56

*King, 1950.
†See text for details.

bers whose temperatures were adjusted to 5°, 24° or 35°C. The turkeys were held in the chambers for 24 hours after which they were weighed individually. They were then shipped 35 miles to a commercial processing plant where they were processed approximately 3 hours after their removal from the environmental chambers. The data in Table 11 show the relative detrimental effect of high temperature and low rate of air circulation. Weight loss significantly increased with increasing temperature. At the highest temperature, 35° C, there was extensive mortality, indicated by the loss of 13 of the original 20 turkeys.

The influence of environmental temperature on chickens and turkeys during the summer months is well known to processors. During periods of elevated temperatures, plant managers may institute several programs to minimize deaths. These include spraying water over the truck, installing shade, using large circulating fans to move air across the short axis of the truck, or if time permits, additional truck travel on the highway to continue air movement and prevent heat accumulation. Because of the necessity of crowding chickens and turkeys in a truck, it is imperative that other techniques of minimizing death and weight losses be developed. An effective approach is to always minimize the amount of time poultry remains on the truck.

PROCESSING

Slaughter:

Under normal operating conditions, slaughter procedures have little or no influence on eviscerated yield. The procedure briefly described is as follows: live birds are taken from crates or racks on the truck and placed on a conveyor. If turkeys are being processed, there will nearly always be electric stunning to immobilize the turkey, minimizing subsequent body activity and bone breakage. Excessive voltage can result in broken wings. keel bones and clavicles, and poor bleeding. Shortly after stunning the birds pass to the station where an external cut is made, severing the jugular vein and/or carotid arteries .The birds are allowed to bleed for a period of about 90 seconds prior to entering the scalder. Because of line speed, variation from one bird to another and variation in the operator's performance, some birds do not bleed adequately and, thus, may be condemned as "underbleeds." Previous research by Newell and Shaffner (1950) indicated that 35-50% of the chicken's blood supply is lost during processing.

Several earlier researchers reported studies on electric stunning (Mountney et al. 1956), the use of carbon dioxide for immobilization (Swanson and Helbacka. 1953; Drewniak et al., 1955; Kotula et al., 1957; and Kotula et al. 1960) and drugs (Newell and Shaffner, 1950; and Huston and May, 1961). No method of sacrificing the animal appears more effective than severance of the jugular vein (Newell and Shaffner, 1950, and Davis and Coe, 1954). Equipment manufacturers recently have expedited this procedure through the development of mechanical killers.

Scalding and Defeathering:

The operations referred to as scalding and defeathering have no influence on yield of eviscerated turkey. Chickens are scalded at temperatures from 53-58° C and turkeys at 60-61° C. Overscalding can result in down grades and thus lower yields. Excessive picking may reduce yield by solubilizing adipose fat or allow for excessive water uptake in chilling. Special procedures, including the of wetting agents and wax dipping, are employed in processing ducks and geese.

Evisceration:

The assembly-line type of operation involved in eviscerating poultry carcasses has considerable effect in the ultimate yield. Line speeds dictate that an individual person will make a minimum of cuts on the individual birds. Unnecessary tears or cuts in the flank area, thighs or rib cage will allow increased water uptake in chilling. USDA regulations limit this incidence. That eviscerated yield is easily influenced by evisceration procedures can be illustrated by considering the point at which the neck and the head are severed. Any retention of the neck with the head would reduce the yield. Automatic neck pullers are routinely used and tend to do a reasonably uniform job, thus minimizing variation. Nevertheless, removal of the head, the kidneys and preen gland, trimming giblets and care in making other cuts significantly affect yield, particularly in leaving or trimming fat from the gizzard.

Table 10. Influence of loading and holding practices on eviscerated yield and carcass quality of turkeys.†

	Loading Time			
	I†‡		II†‡	
	A	B	C	D
Number of turkeys	400	351	312	350
At-farm weight (kg)	4644.83	4558.65	3805.68	4152.68
At-plant weight (kg)	4576.79	4490.61	3755.78	4123.20
Shrink (%)	1.46	1.49	1.31	0.71
At-processing weight (kg)	4576.79	4309.17	3755.78	3946.29
Shrink (%)		4.04		4.29
Moisture absorption				
No. turkeys	44	43	42	37
Av. weight (kg)	8.079±§ 1.304	8.222± 0.709	8.845± 0.765	8.335± 0.964
Moisture (%)	5.15± 1.19	6.22± 1.54	5.00± 1.51	5.13± 1.69

*Marion et al. (1970).
†I represented turkeys loaded by 8:00 a.m.: II represents turkeys loaded by 12:00 noon. B and D groups were held an additional 24 hrs. before slaughter.
‡Each lot represents a half-load of turkeys.
§Mean and standard deviation.

Table 11. The influence of pre-mortem holding temperature on mortality, weight loss, and water absorption of adult male turkeys.*

Factor	Holding temperature (°C) 5	24	35
Number of turkeys	20	20	20
Live weight (kg)	11.612±0.952†	11.476±0.907	11.204±0.840
Mortality (%)	0	0	65
Shrink (%)	3.23 ±1.96	5.20 ±2.35	10.00 ±0.94
Moisture absorption (%)	6.85 ±3.57	7.02 ±3.63	9.48 ±3.77

*Marion et al. (1970).
†Mean and standard deviation.

Average eviscerated yield for chicken broilers after chilling ranges from 73 to 76% (Table 12). An average value for large raoster turkeys is 82% (Table 13).

Trimming Practices:

"Trimmers" are provided by plant management, but they work under the direct supervision of the USDA inspector. Their knowledge of what needs to be trimmed and the extent to which the trimming is done has a vital impact on eviscerated yield, but more importantly, on grade yield. If the trimmer tends to over-trim by a few ounces or removes parts of the entire carcass unnecessarily, serious losses result. Added attention to training of both the trimmers and those on the eviscerating line pays good dividends through improved yields and reduced weight loss.

Chilling Procedures:

Between the mid-fifties and early sixties researchers and equipment manufacturers have attempted to evaluate the role of mechanical chilling of poultry. Other synonyms for this procedure include "continuous" and "spin-chill." The development of the modern broiler industry dictated an immediate change from air chilling procedures to that of water chilling. Initially broilers and turkeys were immersed in tanks of ice slush in which they were often held overnigth and packaged the subsequent day. Upon the development of mechanical chillers, the opportunity to eliminate the ice slush tank with its high cost of labor and space was realized (Marion et al. 1968). Although chickens and turkeys were subject to greater amounts of water absorption in the mechanical chillers (Marion et al., 1970), the major question dealt with the adequacy of the short term chilling procedures in facilitating the necessary aging of the carcasses (Marion and Goodman, 1967). Industry, USDA and university researchers have applied considerable resources to the question of how to control moisture pickup during the chilling operation in mechanical chillers.

Factors affecting moisture absorption, hence yield, include water temperature (Thomson et al. 1961, number of external cuts (Kotula et al., 1960), chilling time (Fromm and Monroe, 1958; Froning et al., 1960; Bigbee et al., 1962), agitation of cooling medium (Klose et al., and Dawson, 1961; Thomson et al., 1961 and Swanson 1960), ratio of ice to water in the cooling medium (Mickelberry et al., 1962; Osner and Shrimpton, 1966) and additives, e.g. polyphosphates (Mountney and Arganosa, 1963; May et al., 1963; Spencer et al., 1963; Schermerhorn and Stadelman, 1964; Hale and Stadelman, 1973). The general consensus is that polyphosphates tend to aid in the retention of absorbed moisture rather than to increase the amount absorbed.

Table 12. Average eviscerated yield of broilers.*

	Males (g) 1600-1700	Males (g) 1800-1900	Females (g) 1400-1500	Females (g) 1500-1700
Hot-cut†: w/o giblets	65.76‡	66.39	65.44	65.93
w giblets	75.17	75.44	75.30	75.48
Chill-cut: w/o giblets	65.49	66.09	65.61	65.78
w giblets	75.12	75.70	75.65	75.67

*Treat, 1971.
†Hot-cut broilers were weighed after they had passed through the final spray washer. Chill-cut broilers were chilled 40 min. in a continuous drag-type chiller at 4° C. drained for 20 min. and weighed.
‡Each mean based on 10-12 broilers.

Table 13. Average age, weight and eviscerated yield of commercially processed turkeys, 1970*

Sex	Plant	Age (wk)	Weight (kg)	Yield (%)
Males	1	23.3±2.0†	12.0±1.3	81.5±1.3
	2	23.5±1.5	11.6±1.2	82.1±1.4
	3	22.7±1.0	10.9±1.1	82.1±1.0
	4	23.6±2.4	11.3±1.6	82.6±0.3
	Av.	23.3	11.4	82.1
Females	1	19.8±1.3	6.9±0.9	81.5±1.0
	2	20.7±1.3	7.0±0.5	82.6±1.4
	3	19.0±1.5	6.2±0.7	82.4±1.7
	4	20.2±2.1	6.6±0.8	83.5±0.4
	Av.	19.9	6.7	82.5

*Acton (1970).
†Mean and standard deviation.

Table 14. Maximum limits of water absorption for all classes of poultry other than turkeys frozen or cooked as whole poultry to be consumer packaged.*

Average ready-to-cook carcass weight prior to final washer (less necks and giblets)	Average percent increase in weight over weight of carcass prior to final washer (less necks and giblets): Zone A† Product shall be retained if more than one test out of 5 exceeds	Zone B† Product shall be retained if any test exceeds
Chickens 1¼ lbs. and under	8.0	8.7
Chickens over 1¼ lbs. and all other classes of poultry other than turkeys	6.0	6.7
To be shipped as ice packed poultry	12.0	13.0
To be cut up	10.0	11.0

*Animal and Plant Health Inspection Service, 1972.
†Product shall be retained if, out of five consecutive tests more than one test exceeds the Zone A limits or any test exceeds the Zone B limits. These zone limits were based on a statistical analysis of variation between individual birds with regard to moisture absorption. With these limits the chance of passing a lot with average moisture at or above the Zone A limit is less than 15 percent. A lot with average moisture at or above the Zone B limit would have virtually no chance of passing.

Table 15. Maximum limits of water absorption for all turkeys to be consumer packaged, frozen or cooked.*

Average ready-to-cook carcass weight prior to final washer (less necks and giblets)	Average percent increase in weight over weight in carcass prior to final washer (less necks and giblets): Zone A Product shall be retained if more than one test out of five exceeds these limits	Zone B Product shall be retained if any test exceeds these limits
Less than 8 lbs. 8 ozs.	8.0	9.0
8 lbs. 9 ozs.—15 lbs. 15 ozs.	6.0	6.4
16 lbs.—16 lbs. 15 ozs.	5.8	6.05
17 lbs.—17 lbs. 15 ozs.	5.5	5.75
18 lbs.—18 lbs. 15 ozs.	5.3	5.55
19 lbs.—19 lbs. 15 ozs.	5.1	5.35
20 lbs.—20 lbs. 15 ozs.	4.9	5.15
21 lbs.—21 lbs. 15 ozs.	4.8	5.05
22 lbs.—22 lbs. 15 ozs.	4.6	4.85
23 lbs.—23 lbs. 15 ozs.	4.5	4.75
24 lbs.—26 lbs. 15 ozs.	4.4	4.65
27 lbs. and over	4.3	4.55

*Animal and Plant Health Inspection Service, 1972.

The benefit of water chilling of poultry, unlike that of red meat animals, is that the water protects the skin surface against dehydration and discoloration. The benefit of added water to the processor's yield is obvious. The regulations on allowed moisture pickup (Tables 14 and 15) have been changed in some detail in the last decade but, generally, they reflect tolerances in terms of the amount of water that would naturally be absorbed in a tank chilling operation.

Whole turkeys (12 and 20 lb.) that had (a) 1 hr. spin-chill, (b) 1 hr. spin-chill plus 3 hr. slush ice, or (c) 1 hr. spin-chill plus 23 hr. slush ice, prior to freezing at a commercial processing plant were thawed in a refrigerator or in cold running water, then roasted in foil at 450° F to 180° F. (Brodine and Carlin, 1967). Overall losses were not affected by thaw method; but 12 lb. turkeys chilled 1 or 4 hr. had 24% losses and those chilled 24 hr. had 28% losses. For the 20 lb. turkeys overall losses of 28% were similar regardless of treatment.

Various methods of chilling dressed broilers are being used by processors. Mechanical chilling still appears to be the standard, but several variations of mechanical chilling and/or carbon dioxide chilling have been tried (May et al., 1966; Shantz et al., 1967; Lee and Strawn, 1971; Risse and Thomson, 1971; and Thomson and Risse, 1971). Advantages of reduced use of mechanical chilling and increased use of CO_2 and lower refrigeration temperatures are listed as: (1) less moisture pickup by the birds, (2) more meat per box, (3) more meat per truck load, (4) no weepage, (5) less labor, and, (6) more attractive product (Lee and Strawn, 1971). Added costs of refrigeration and CO_2 and the lack of a fully developed retail system to handle the new forms of fresh chicken are obvious disadvantages.

Another technique of carcass chilling now being investigated is spray-chilling. Opponents of mechanical chilling argue that the large volume of water serves as a common bath to facilitate contamination of several poultry carcasses by just one contaminated carcass. However, May (1974) found that continuous immersion chilling significantly reduced bacterial counts. Although spray-chilling may be ideal from the microbiological point of view, questions on an available water supply, increased refrigeration cost and the increased effluent from the processing plant raise major problems for the industry. Industry, nevertheless, is aware that countries within the European Economic Community have declared that they will not import poultry from the United States after 1977 that has been mechanically chilled (Veerkamp et al., 1972).

PREPARATION

Phosphates, NaCl and Cooking Losses:

Commercial polyphosphates were used in the red meat industry some time before their use was adopted by the poultry processors. Schermerhorn et al. (1963) investigated the effectiveness of food grade phosphates in controlling water uptake during chilling as well as in retaining the moisture that had been absorbed. Increasing the level of phosphates in the chilling media from 4 to 12% decreased the water uptake from 5.74 to 3.25%. The level and type of phosphate also influenced the yield of the fried product. Phosphate treated carcasses had 2.47% less cooking losses than the controls (35.07% vs. 32.60%).

Increasing time of chilling in the phosphate solution was observed to influence the water absorption by broilers (Mountney and Arganosa, 1963). Carcasses that were chilled either 2 or 8 hours in commercial polyphosphate (Kena) solutions absorbed less moisture, but when they were held 24 hours in the chilling media no significant difference in moisture absorption was observed. When carcasses were held in crushed ice or frozen and thawed, the carcasses that had been chilled in polyphosphate solutions lost less weight than those chilled in slush ice or 4% phosphate plus sodium chloride. Cooking losses were approximately 4% less for carcasses chilled in 6% Kena than those for the controls (32.6 vs. 27.3, respectively). Four percent sodium phosphate or 4% sodium phosphate plus sodium chloride gave intermediate results.

In comparing 4, 8 or 12% phosphate in the chilling water for fowl, Schermerhorn and Stadelman (1964) again observed a decrease in water absorption with the increase in level of phosphate. Cooking losses were lower for the phosphate treated hens, but this difference was not significant. Twelve percent polyphosphate in the chilling media resulted in approximately 2% greater cooking loss for the heavy hens when compared to the controls. Cooking losses were similar for all treatments in the Leghorn fowl. Similar results were observed by Monk et al. (1964). Hens cooked in an electronic oven or at 100° C plus 6.8 kg. pressure had the same loss during cooking regardless of whether or not they had been treated with polyphosphates. However, broilers treated with phosphates did exhibit less cooking losses when cooked by either electronic oven or the heat plus pressure.

Farr and May (1970) compared the effect of polyphosphates and sodium chloride in increasing yields and product stability. Three methods of application were used: incorporation into the cooking media, injection into the product, or cooling in the solutions post-cook.

These authors noted that polyphosphates or sodium chloride in the cooking water at a level of 3% reduced the cooking loss. Injecting up to 7% of a solution of 5% polyphosphate 10% sodium chloride (0.3% phosphate in the muscles) also reduced cooking losses. Cooling the cooked product in the polyphosphate solution did not influence the yield, but phosphates were detectable in the tissue. Cooking in solutions of sodium chloride of either 1.0 or 1.5% caused a reduction in cooking loss when previously frozen carcasses were used. This reduction in losses was not observed when fresh carcasses were used.

Marinating chicken in either polyphosphate and/or salt for 16 hours prior to frying was investigated by Baker et al. (1972a). Marination of the chicken in 3% polyphosphate increased the cooked yield by 8% and total moisture by 2% as compared to the unsoaked controls.

Cooking Methods:

In reviewing the literature for the past 10 years, it is difficult to find data that are pertinent to today's processes. Most of the literature covers methods of cooking that were used by institutions and housewives in preparing chickens and turkeys for their own use. Many of the cooking methods are not adequately described. While in many instances, cooking and the determination of doneness are still parts of an art, even this must be adequately described so it can be duplicated or so the data can be interpreted.

Turkeys:

The most reported method for cooking turkeys is by roasting either in an open pan or foil wrapped. The oven temperatures reported vary from 163° C to 204° C. Likewise, end point temperature, as a measure of doneness, varied from a low of 54° C to a high of 95° C.

Boneless thighs and breasts of six commercial strains of turkeys were evaluated for yield by Goertz et al. (1962). Roasting was the method of cooking used with an oven setting of 176° C, and the roasts were cooked to an end point temperature of 95° C. Toms being heavier yielded more breast meat (3.0 kg. vs. 1.5 kg.) and more thigh meat (1.4 kg. vs. 0.7 kg.) than the hens. Percentagewise, toms yielded 32.5% breast meat and 14.6% thigh, whereas hens yielded 30.8% breast and 15.2% thigh (Fry et al. 1962). Turkey hens had a greater cooking loss for the breast (26.8%) than the toms (24.8%) but a lower cooking loss for the thighs (29.0% vs. 30.0%). The number of servings (71 g.) per pound was similar for toms and hens and average 3.5 for the breast and 2.9 for the thigh.

Augustine, et al. (1962) reported than on the basis of ready-to-cook weights of whole 19 lb. turkeys that were roasted at 150° C and cooked to 85° C in the thigh, the edible sliceable meat yield was 35%. For turkey rolls, the average percentage yield was 73% for 6.5 lb. breast meat rolls cooked to 80° C and 62% for 2.81 lb. thigh meat rolls cooked to 85° C.

Travnicek and Hooper (1968) compared braising and roasting for preparing frozen breast quarters. An oven temperature of 163° C was used and all quarters were cooked to an end point of 86° C. Roasting of the breast quarters resulted in greater total cooking loss and volatile loss but less drip loss when compared to braising. Roasting of the meat required approximately 11 minutes longer to reach the desired end point temperature.

Frozen or defrosted turkey halves were cooked utilizing pressure (15 psi) or braising at two different oven temperatures, 163° C or 176° C to an internal temperature of 80° C measured in the breast (Ibbetson, et al., 1968). Average total cooking loss for halves cooked by pressure were 27.2% for the frozen ones and 25.4% for those defrosted. Total cooking loss for frozen and defrosted halves braised at 163° C was 17.7 and 15.3%, respectively, compared with 19.5 and 16.2% for frozen and defrosted halves braised at 176° C. When drip loss for defrosted halves was added to total cooking loss, differences in losses for frozen and defrosted halves were negligible.

Turkey bars composed of 60% breast, 27% thighs and 13% skin were cooked by braising or water immersion cooking (Fry et al., 1964). An oven temperature of 163° C and an end point temperature of 85° C was used for braising. Either a constant or a variable temperature was maintained in the water and the product was cooked to 80° C end point. When determined immediately after cooking, total cooking losses for oven braising were greater than for water cooking (29.9% vs. 28.9%) and after cooling the losses were even greater (32.9% vs. 31.2%). Cooking in variable water temperature resulted in sligthly higher losses than using a constant temperature.

Age of bird, aging time in slush ice, sex and strain were reported to influence the cooked yield of turkeys (Mostert et al., 1966). Cooked weight as a percent of the frozen weight decreased with an increase in age and toms were superior to hens in yield. Likewise, increasing the aging time from 0 to 24 hours decreased the yield of cooked meat.

Cooking losses and servings per pound were similar for U. S. Grade A, B and C turkeys (Goertz et al., 1962). Edible yield of the cooked meat ranged from 34.4 to 39.1% of the ready-to-eat weight; approximately 60% was light meat and 40% was dark.

Precooking of turkey roasts of three different final temperatures was investigated by Cash and Carlin (1968). Foil wrapped roasts were cooked to an internal temperature of 54° C, 66° C or 77° C in a 204° C oven. Roasts precooked to 66° C and 77° C were reheated to 54° C; whereas, the roasts that were precooked to 54° C were reheated to an internal temperature of 66° C. Total weight loss was compared for the precooked roasts as well as with raw roasts frozen at 0° F and then roasted in foil at 204° C to 77° C. Cooking losses for the different methods of preparation are shown in Table 16.

Precooking and reheating of turkey by a microwave or conventional gas oven were evaluated by Cipra et al. (1971). Total cooking losses were significantly greater for meat cooked in the microwave oven as compared to the gas oven. Precooking of turkey meat in the microwave resulted in a loss of 32.2% and reheating lost an additional 12.5%. Turkey meat cooked with a conventional gas oven lost 25.8% during precooking and 9.6% upon reheating.

Three procedures for roasting turkeys were investigated as follows: (1) openpan, low oven temperature (163° C); (2) loose foil wrap, low oven temperature, and, (3) tight foil wrap, high oven tempertrue (233° C), (Deethardt et al., 1971). Roasting was done on halves with all halves cooked to an internal thigh temperature of 85° C.

Table 16. Effects of precooking on yield.*

Cooking Methods	Loss (%)
Raw—cooked to 77° C	24
Precooked to 54°—Reheated to 66°	30
Precooked to 66°—Reheated to 54°	33
Precooked to 77°—Reheated to 54°	35

*From Cash and Carlin, 1968.

Total cooking losses for the three cooking methods are shown in Table 17.

Chickens:

In preparation for deep-fat frying of broilers, some type of coating is usually applied to the surface of the poultry. The percent gain in weight after dredging (dipping the broiler part in milk and then in a mixture of wheat and potato flours) averaged 4% for halves of medium weight fryers (Hanson and Fletcher 1963), 7.5% for legs, thighs and breasts of 13-week fryers (Carlin et al., 1959) and 8.5% for legs and breasts, and 10% for thighs of 11 week broilers (Taylor, 1959).

In a study by Carlin et al. (1959) the coated chicken parts were precooked for 3 or 10 minutes in deep fat, stored at 0° F for 15 weeks, then thawed and reheated in an electric fry pan. Coated breasts, thighs and legs that were deep-fat fried for 3 minutes had a 4.5% net gain in weight, those fried for 10 minutes had a net loss of 2.6%. Additional weight losses occurred during cooling prior to packaging of 1.5% and 3%, respectively.

After storage at −18°C for 15 weeks, precooked broiler parts were thawed and heated in oil (180° C) to 85° C. Reheating losses were 23% for samples precooked 3 minutes and 14% for those precooked 10 minutes. Taylor (1959) reported net loss of 15% for coated legs, thighs and breasts deep-fat fried for 10 minutes prior to freezing. After storage at −18° C for 32 weeks, the precooked, frozen broiler parts were reheated for 15 minutes in one-fourth inch of fat in an electric fry pan. Reheating losses were only 4%.

Cooking broilers prior to freezing resulted in a smaller drip loss, but greater total losses than freezing in the raw state (Mickelberry and Stadelman, 1962). Five different methods of cooking were evaluated by these authors. Roasting broilers wrapped in foil had the least amount of cooking loss (13.9%) while broilers cooked with a combination of deep-fat frying and microwave reheating exhibited the largest percentage of cooking loss (22.1%). Other cooking methods were intermediate to the two treatments.

Smith and Vail (1963) compared three methods of frying: skillet, deep-fat frying and oven frying for preparing broilers. Skillet frying produced the highest percentage yield (62.3%) followed by deep-fat (58.6%) and oven frying (57.2%). Percent yield of meat varied with the piece; breast and thigh were the highest yielding pieces of those containing skin and bone, and the wing was the lowest yielding part. When considering the yield of edible meat, skillet-fried pieces yielded 41.4%, deep-fat fried parts yielded 39.1%, and oven fried chicken yield 28.4% meat.

Table 17. Effects of cooking conditions on yield.*

Treatment	Total cooking loss % Open pan	Total cooking loss % Foil	Drip % Open pan	Drip % Foil	Volatile % Open pan	Volatile % Foil
0 storage—low oven temp.	26.6‡	22.6	10.3	14.9	16.3	7.8
6 mo. storage— low oven temp.	21.9	22.1	8.0	13.5	13.9	8.5
Open pan at 163° C foil at 233° C	19.0†	23.0	2.5	11.2	16.8	11.5

*From Deethardt et al., 1971.
†P<0.05.
‡P<0.01.

Cooking losses and chemical composition of leg and thighs cooked by five different frying methods were reported by Mostert and Stadelman (1964). Breading decreased weight loss for all cooking methods tested (20.3% vs. 37.7%). The non-breaded thighs lost the largest amount of weight (40%); whereas the breaded thigh lost only 20.4%. Methods of cooking greatly influenced the total cooking loss. Pan fried parts lost the most weight (37.0%) followed by deep-fat +0 pressure (31.3%), oven frying (28.0%), deep fat + 30 psi (24.9%) and deep-fat + 9 psi (23.8%). Freezing of the parts appeared to increase weight loss as compared to non-frozen parts, but this difference in weight was not significant.

In a study investigating the feasibility of using an edible coating, coated pieces of chicken had an average cooking loss of 32.5% while the mean for the uncoated parts was 29.2% (Funk et al., 1971). Lower average cook losses were noted for breast side with the bone attached.

Essary et al. (1968) used three methods of cooking broilers and studied their influence on free moisture, bound moisture and total moisture. These workers observed that a difference in moisture content did exist for birds cooked in boiling water. Average content of free moisture was aproximately 14% greater in muscles cooked attached to bones as compared with bone-free muscles.

Carlin (1947) reported that halves of roasters of fowl (805g.) roasted at 150° C to 90° C had cooking losses of 28%. Aging for 30 minutes, 1, 2, 6 or 24 hrs. of freezing for 24 hrs. at −18° or −35° C had no significant effect on cooking losses.

Precooking and Breading:

Hanson and Fletcher (1963) reported chicken parts cooked prior to applying batter was the most effective method found for reducing the peeling tendency of breadings on frozen fried chicken. The thinner the batter coating, the less was the peeling tendency. Yield of the cooked parts varied from 66 to 104% depending on the number of coating layers applied to the raw chicken.

Studying precooking procedures before deep-fat frying, Hale and Goodwin (1968) obtained yields of 85 and 90% in two separate trials. Breaded yield, expressed as a percentage of raw weight, varied between 110 and 120% before cooking. Precooking by microwave or steam before frying gave a better yield than total deep-fat frying. The microwave unit used in this study was a household model and yields would not be as high as industrial units. If steam equipment is unavailable, comparable results can be obtained by filling a desiccator with water to the bottom of the plate then bringing the water to a boil. Place the chicken parts on the plate and continue cooking.

Precooked Leghorn fowl compared favorably with meat-type fryers for precooked batter fried chicken (Baker and Darfler, 1968). The yield of the fowl was not as good as for the fryers. Fryers that were cooked before being frozen had a cooked yield of 83.4% and those frozen before cooking yielded 83.1%. Freezing did not influence the yield of fowl either. The yield for fresh cooked and frozen fowl was 62.6%.

Steam cooking of chicken at 5 psi for 9 minutes reduced the yield when compared with microwave cooking (Table 18 Webb and Goodwin, 1970). This method of precooking decreased the yield of the thigh more than that of the other parts cooked. Both cooking method and piece affected cooked yield.

The two cooking methods differed in the percent cooking yield, with breast showing a higher cooked yield than either the drumstick or thigh when expressed as a percent of the raw weight. Steam cooking was equivalent to microwave cooking in yield only for drumsticks, but this cooking method produced lower yields for the breasts and thighs. Including cooked ground skin in the batter increased the cooked yield. The breast retained more batter (26.6%) than did either the drumstick (21.4%) or the thigh (20.6%).

Yingst et al. (1971) conducted studies to elucidate the influence of steam and water cooking procedures and breading techniques on the yield of precooked broiler parts. The cooking methods tested had no effect on the yield of the unbreaded parts (Table 19). The wings gave the highest percent cooked yield when unbreaded, followed by drumsticks, thighs and breasts.

The influence of single versus double breading and two steam pressures on yield was studied by Wyche and Goodwin (1971). The second application of breading increased the breading on the parts by 6.9%. The double breaded parts showed an increase of 6.4% for product yield over the single breaded parts.

Eight methods of precooking and batter-breading application were evaluated by Baker et al. (1972a). Of the precooking methods tested, simmering showed slightly greater yield. However, the most desirable product on the basis of shear value, total moisture and yields was made by breading, battering and breading, frying for 20 seconds, steaming and then refrying for 20 seconds. The yields for light and dark meat are presented in Table 20.

In a companion study, Baker et al. (1972b) compared predusting materials in producing a precooked, browned fried chicken. High protein materials produced crusts with better adhesion than starches, gums or alginates. High adhesion scores resulted in low cooking losses and high yields with dried albumen producing the lowest cooking loss (8-9%) and highest yields (116%).

May et al. (1969) devised a simple method to determine the batter and breading content of finished breaded poultry products. The breaded chicken was weighed, placed in a container of water and agitated with compressed air for a standard time to remove breading. The meat was blotted on paper toweling to remove excess water, then reweighed. This method gave highly significant correlations (0.61 to 0.99) with known breading content. This method was not suitable for all products because of loss of product integrity or failure to solubilize the breading.

Poultry Meat Yields as Influenced by Further Processing and Preservation

FURTHER PROCESSING

Fry et al. (1962) reported an average cutting loss of 0.5% for both turkey hens and tom carcasses without giblets when they were cut into seven pieces. The bone yield (keel and back rib bones) averaged 7.9% for hen carcasses and 8.5% for toms. Bone weights of thighs, drumsticks, wings, back and necks were not determined.

Miller (1968) reported an average boning loss of 2.1% in converting whole turkey carcasses without giblets and necks to completely separating all the meat and skin from the bones. As shown in Table 5, bone yield varied from a low of 22.6% for approximately 11 kg. tom turkey carcasses to a high of 31.1% for approximately 7 kg. carcasses. With this large variation in bone weight, no significant differences in meat yield were observed between turkey carcasses weighing from 6.51 kg. to 14.36 kg. Larger tom turkey carcasses had significantly more skin than the smaller turkeys. Turkey thighs yielded 77 to 83% meat and 7 to 11% skin. Skin yield increased with carcass size while meat yield did not. Turkey

Table 18. Yield of chicken parts as influenced by microwave vs. steam cooking.*

Part	Raw %	M.W. %	Steam (5 psi) %	Avg.
Breast	126.6	100.2	95.5	107.5
Thigh	120.6	94.1	88.7	101.1
Drumstick	121.4	93.6	92.4	101.0
Av.	121.4	95.9	92.2	
% Breading	18.6	21.1	20.4	

*From Webb and Goodwin, 1968.

Table 19. Effects of breading and various cooking methods on yield.*

Treatment	Cooked Yield† Unbreaded %	Breaded %
Water cooking	84.8	-----
Steam cooking		
0 Pressure	85.0	92.0
5 Psi	83.5	90.5
15 Psi	84.0	88.6
Parts		
Drumsticks	85.4	89.0
Thighs	82.4	89.4
Breasts	81.0	92.5
Wings	88.5	90.6

*From Yingst et al., 1971.
†Yield calculated as percent of raw weight. Breaded parts were breaded then steam cooked.

Table 20. Effects of cooking method on yield of light and dark meat.*

Cooking Method	Cooked Yield (%) Light	% Crust	Dark	% Crust
Steam	101.2	22.1	99.9	19.2
Simmer	101.4	22.0	101.0	24.4
Boil	98.2	20.2	99.2	19.3
Deep-fat fry	97.9	23.8	96.6	22.1

*From Baker et al., 1972a

drumsticks varied between 59 and 63% meat and 6 and 9% skin with both qualities increasing as carcass weight increased.

MacNeil (1969) found that deboned skinless breast meat yielded 31.9 to 39.9% of the dressed carcass weight. The skin covering the carcass except wings and drumsticks accounted for 5.1 and 10.4% of the carcass weight, with the neck skin accouting for as much as 47% of the total skin weight.

Comparing boning of hot turkey carcasses to chilled turkey carcasses, Nixon and Miller (1967) found total meat yield to be 2% greater from hot boned toms than from cold boned toms and 1% more for cold boned hens than from hot boned hens. The conclusion was made that boning method did not affect yield as much as other factors. Mean cooking loss of rolls fabricated from cold boned turkey carcasses was 1.4% greater in the hens and 2.3% greater in the toms than the rolls from the hot boned carcasses. Sex affected cooking loss in that toms had significantly less cooking loss irrespective of treatment.

Working with boned Leghorn fowl meat, Breclaw and Dawson (1970) reported that light meat gave a higher yield than dark meat when fabricated into smoke flavored rolls. No yield data were presented.

Schnell et al., (1971) reported the primary grind and the secondary screen size to influence the yield and chemical composition of mechanically deboned chicken meat. In general, the larger primary grind resulted in a higher yield (52% compared with 42%) and a lower amount of solids (33% compared with 38%).

Baker et al. (1970a) reported on the influence of three different casings on heating loss and yield of chicken frankfurters. No significant differences were found between cellulose casings (8.7% heating loss) and collagen casings (10.3% heating loss) or natural casings (9.2% heating loss). Yield of chicken frankfurters with collagen casings was lowest (81.8%) compared to those with cellulose and natural casings (83.3% and 83.2%, respectively). No information on statistical variation was given concerning yield data. Additional work (Baker et al., 1970b) found that using fryer meat resulted in an average heating loss of frankfurters of 9.9% while using hen meat resulted in a heating loss of 20.3%. Frankfurters made with turkey meat lost 21.2% upon heating. Frozen fryer chicken meat resulted in 11.1% heating loss in chicken frankfurters while fresh fryer meat produced frankfurters with 9.2% heating loss.

PRESERVATION AND STORAGE

Spencer et al. (1956) reported that turkey cooled in ice water gained the most weight during cooling and lost the highest percentage during thawing compared to those cooled in snow, ice or canvass or polyethylene bags. Turkey fryers and young tom carcasses lost the greatest amount of weight (2 to 4%) during thawing while young hens and mature hen carcasses lost the least weight.

Marion and Stadelman (1958), working with chicken fryers, fowl, turkey fryers and mature turkey toms, found that method of freezing (liquid, plate or moving air) had no effect on percentage drip or percentage of total cooking loss.

Brant et al. (1967) reported a drip loss after freezing varying from 2.3 to 5.7% for chicken carcasses and 3.3 to 3.9% for turkey carcasses. These drip losses were based on chilled weight. The presence of several common poultry diseases, the prime variable in this study, did not show any effect on thawing loss. The authors associated the low level of thaw loss in one group to fewer cut surfaces from trimming.

Wladyka and Dawson (1968) reported the percent drip to be higher from light meat than dark meat of heavy chicken hens after frozen storage. The percent drip was greater after 90 days frozen storage compared with 30 days of frozen storage. Protein losses due to drip amounted to 1 to 4% of the weight of the original meat sample.

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