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# Effects of Cooking Methods and Browning Temperatures on Yields of Poultry Parts[1]

B. E. LOVE[2] AND T. L. GOODWIN
*Department of Animal Sciences, University of Arkansas, Fayetteville, Arkansas 72701*

(Received for publication October 29, 1973)

*ABSTRACT* Effects of cooking methods and browning temperatures on yields, rancidity development, and tenderness of broiler parts were investigated. Broiler parts breaded raw and steam cooked picked up more breading than parts breaded after being cooked in water. Wing and breast parts were observed to pick up the greatest percent of breading. Water cooked chicken had more initial cooking loss than the steam cooked parts during the precooking operation. Wings, regardless of cooking method, lost the least amount of weight during this operation. Browning in deep fat resulted in greater weight losses for steam cooked parts than for water cooked chicken. Wings were shown to have the greatest percent weight loss in the deep fat fryer. Weight loss in the fryer rose progressively as browning temperature was decreased and time of browning increased. Drums and wings had the highest final yield and thighs had the lowest yield.

Steam cooked parts were found to be more tender than water cooked parts. The second 3 mm. slice of the *pectoralis major* muscle of the breast was found to be more tender than the first 3 mm. slice. The *iliotibialis* muscle of the thigh was more tender than either the outer or inner layer of the *pectoralis major.* Deep fat frying increased the shear values recorded for breasts, but not for thighs.

TBA numbers were found to be lower for breast meat than thigh meat. Parts browned at 149° C. had the highest TBA numbers of the treatments studied.

POULTRY SCIENCE 53: 1391–1398, 1974

## INTRODUCTION

COOKING poultry meat brings about changes in magnitude that depend on the chemical composition of the meat and the stage of doneness to which it is cooked. Characteristic changes during cooking are changes in flavor, loss in weight, contraction in volume, and structural changes of connective tissues, muscle fibers and fatty tissues.

Lowe (1958) reported a number of factors which might influence cooking losses. Among those factors discussed were the degree and distribution of fatness, covered *vs.* uncovered pans, double *vs.* single cooking periods, time and temperature of cooking and the stage

1. Published with the approval of the Director of the Arkansas Agricultural Experiment Station
2. Present address: Ocoma Foods, Berryville, Arkansas

of doneness. Investigators have also found that method of cooking and the part cooked have an effect on yields. Webb (1969) found that steam cooking resulted in higher cooking losses than microwave cooking. In this study, the drumsticks were shown to have a higher cooked yield than the breast or thigh parts. Additional information concerning cooking methods and breading techniques was given by Yingst (1970), who found that cooking method had no effect on the unbreaded yield of parts cooked in steam or water. It was observed in this study that unbreaded wings gave a higher cooked yield than did the drum, thigh or breast parts.

Tenderness in poultry meat is one of the most important attributes of quality. Mickelberry and Stadelman (1962) noted significant differences between the first and second slice of breast muscle in chicken. These workers found the thigh to be intermediate in tenderness to the two slices of breast muscle. Results of this nature are in accordance with information collected by Wise and Stadelman (1961), who found that resistance to shear was related to the depth at which samples were taken. Goodwin *et al.* (1962) also found the outer layers of the *pectoralis major* muscle of turkeys to be significantly less tender than inner layers. This finding has also been verified by Yingst (1970) using broilers. In contrast to the above findings, Yingst (1970) found no significant difference between the first and second slice of the *pectoralis major* muscle of breaded breast from broilers.

Oxidative rancidity has been shown to be responsible for objectionable odors and flavors which develop during storage in muscle tissue subjected to thermal treatment (Tims and Watts, 1958). Webb (1969) studied the development of rancidity in precooked, frozen chicken parts. Results from this study indicated that cooking method, storage time and batter formula had little effect on 2-thiobarbituric acid. Webb (1969) found that ice slush cooling of cooked parts gave much lower TBA numbers than did those parts cooled at room temperature. Recently, investigations have been made to determine changes in products that result because of deep fat frying. Since TBA number has been found to be correlated to the total fat of the product (Webb, 1969), any cooking method that increased the fat should be investigated.

The objective of these experiments was to provide information concerning cooking methods utilized by the commercial producer of precooked chicken and also the browning temperatures employed to reconstitute the product at the institutional level. The treatments studied in these experiments were evaluated by measuring their effects on yields, rancidity development, and tenderness of the broiler parts.

## EXPERIMENTAL PROCEDURE

*Experiment 1.* Three hundred parts each of the breast, thigh, drum and wing were obtained from the cut-up line of a local processing plant. All parts were packed in ice, brought back to the laboratory and stored in a refrigerator at 4° C. for a minimum of 24 hours prior to being assigned to a cooking treatment. Parts were divided into groups consisting of 10 parts each of the breast, thigh, drum and wing. The cooking treatments consisted of cooking to complete doneness as determined by end point temperature in either water or steam and finishing by browning in a deep fat fryer. The browning operation was intended to simulate the procedure used by an institution that would serve the product.

One-half of the parts for each day's cooking was assigned to the water cooking treatment. These parts were weighed to the nearest gram in lots of ten and placed directly into an open kettle containing 12 liters of water, which had been preheated to 80° C. The parts were suspended in the kettle by the use of a wire tree so that equal heating could be obtained for all parts and compressed air was bubbled into the cooking medium creating a stirring action which permitted a more uniform temperature. Ten breasts and ten thighs were cooked together for one hour and equal numbers of drums and wings were cooked together for 50 minutes. Heat was supplied for the cooking process by a large hot plate with temperature variation of 77° C. to 83° C. during the cooking process. The parts were allowed to cool at room temperature for 10–15 minutes before being weighed.

The remaining half of the parts for one day's cooking was cooked in a steam autoclave (retort) at atmospheric pressure. All parts were placed in the autoclave on a commercial cooking rack and the time of cooking was set after the autoclave reached 101° C. Breasts and thighs were cooked a total of 18 minutes with drums and wings being cooked for 14 minutes. Procedure for cooling and weighing was the same as that used for water cooked parts.

Breading techniques were the same for the two cooking methods with the exception that the steam cooked parts were breaded in the raw state, whereas water cooked parts were breaded after being cooked. The two precooking and breading procedures were used to simulate commercial operation. Breading was achieved by using a spin type Henny Penny breading machine and commercial breading material.

After the parts were completely cooked and breaded by the methods previously described, they were browned in a conventional deep fat fryer. Cooking oil temperature and time of browning were varied in this procedure to insure uniform browning. Preliminary investigations revealed that in order to maintain a uniform brownness, the following time and temperature relationships should be employed:

| Browning temperature | Time |
|---|---|
| 149° C. | 7 Minutes |
| 177° C. | 4.5 Minutes |
| 205° C. | 2 Minutes |

Equal numbers of parts were browned using one of the above treatments, allowed to drain and cool for 10–15 minutes at room temperature before the final weight was taken.

Proctor and Gamble "Frymax" oil was used in both experiments. Burnt particles were filtered from the oil and it was frozen after each day's use. New oil was added to compensate for product absorption.

*Experiment 2.* The objective of this study was to determine the effects of precooking methods and browning temperatures on tenderness and rancidity development. Only breast and thigh parts were used; otherwise, all handling and processing procedures were identical to those utilized in Experiment 1.

After precooking, the parts were divided into three groups: parts not browned (NB), and those parts browned at either 149° C. or 205° C. "Frymax" oil was also used in this experiment. Since the condition of the oil could become a factor, the used oil was replaced by new oil after half the replications had been completed. During this experiment samples of the cooking oil were analyzed for TBA values to make sure oil quality would not interfere with the accuracy of product analysis. Otherwise, the frying oil was treated exactly as in Experiment 1.

Immediately after the browned parts were taken from the deep fat fryer and the nonbrowned parts were taken from the water or steam cooker, the parts were put in polyethylene bags and placed in a home style freezer for one hour to eliminate the heat within the product. Next, the parts were transferred to a refrigerator maintained at 4° C. where they were held for 16 hours prior to being analyzed for tenderness and rancidity.

The method of rancidity evaluation used in this experiment was the distillation procedure for determining 2-thiobarbituric values in meat as described by Tarladgis *et al.* (1960). Certain carbohydrates react with TBA to give a yellow or orange color with absorption maxima at 450-460 mμ. (Yu and Sinnhuber, 1962). Since absorption spectra overlap each other, the determination of malonaldehyde in foods containing these compounds will be misleading. For these reasons it was deemed necessary to remove all breading from the parts before they were chemically analyzed for TBA values.

To remove the breading, all parts were placed in a large metal container and submerged in tap water. Parts were agitated by means of compressed air for 45 minutes before being taken out and hand rubbed until all breading was removed. After each application was cleaned, it was placed in the refrigerator and later removed one bird at a time for shear press and TBA samples.

As bags were removed from the refrigerator, the first and second 3 mm. slice of the *pectoralis major* muscle of the breast and the *iliotibialis* muscle of the thigh were removed for shear press samples. Samples to be sheared were wrapped in aluminum foil and held in the refrigerator overnight before being sheared. The samples were weighed to the nearest tenth of a gram prior to being sheared with an Allo-Kramer shear press equipped with a 2500 pound ring. A Varian recorder set on the ten percent range was attached to the shear press.

After shear samples had been taken, the remaining skin and muscle was stripped from the bone and used for TBA determination. Transmittance was determined for each sample, converted to optical density, which was multiplied by a factor of 78.43 and the result divided by sample weight to give the mg. of malonaldehyde per 1000 g. of meat (the TBA number).

TABLE 1.—*Treatment means for percentage breading and cooking losses*

| | Breading[1] uptake (%) | Initial[2] cooking loss (%) | Browning[3] loss (%) | Total[4] cooking loss (%) |
|---|---|---|---|---|
| Grand mean | 4.9 | 12.1 | 22.9 | 32.2 |
| Precooking method | | | | |
| Water | 3.9[a] | 16.7[a] | 18.7[a] | 31.9[a] |
| Steam | 5.8[b] | 7.4[b] | 27.1[b] | 32.5[a] |
| Part | | | | |
| Drum | 3.4[a] | 11.6[a] | 21.6[a] | 30.7[a] |
| Wing | 5.6[b] | 8.7[b] | 25.3[b] | 31.6[a] |
| Breast | 5.9[b] | 13.8[c] | 21.8[a] | 32.5[b] |
| Thigh | 4.6[c] | 14.2[c] | 23.0[c] | 33.8[c] |
| Browning temperature | | | | |
| 149° C. | | | 25.8[a] | 34.6[a] |
| 177° C. | | | 24.1[b] | 33.8[a] |
| 205° C. | | | 18.8[c] | 28.2[b] |

Means within each treatment followed by different letters differ significantly ($P < 0.05$).
[1]Percent breading adhering to the parts is based on the raw weight of the parts.
[2]Percent initial cooking loss is based on the raw weight of water cooked parts and on the breaded weight of steam cooked parts.
[3]Percent loss due to browning is based on the cooked weight of steam cooked parts and on the breaded weight of water cooked parts.
[4]Percent total cooking loss is based on the breaded weight of steam cooked parts and on the raw weight plus breading picked-up by water cooked parts.

Statistical examination of the data for both experiments was by factorial analysis of variance and Duncan's new multiple range test as described by Steele and Torrie (1960).

## RESULTS AND DISCUSSION

In Experiment 1, two cooking methods (water or steam) and three browning temperatures (deep fat frying at 149° C., 177° C. or 205° C.) were compared to determine their effects on cooking losses of cut-up broiler parts. Chicken parts that were breaded prior to steam cooking, which involved breading in the raw state, had better breading adhesion and breading uptake than those parts breaded after water cooking (Table 1). Data from Table 1 also indicate that wing and breast parts picked up the greatest amount of dry breading. These results might be explained by considering the larger surface area in relation to weight of the light meat parts.

Steam cooked parts were observed to lose 9.3 percent less weight than water cooked parts during the precooking operation (Table 1). This effect was thought to be largely due to the protective coating given by the breading, which seemed to seal in and/or soak up the juices normally lost in the steam cooking process. The effects of breading prior to cooking may not be accurately compared in this experiment because of the two different cooking methods used. However, evidence has been provided by previous experiments in this laboratory that indicated no difference in cooking loss results from water or steam cooking of unbreaded parts (Yingst, 1970). Since the cooking procedures of the work previously mentioned and the ones followed in this study were similar, it was postulated that differences found were solely the result of different breading times of before and after cooking. Of the parts studied, wings had the highest precooking yield while breasts and thighs had the lowest.

Parts that were steam cooked prior to browning lost 8.4 percent more weight than water cooked parts (Table 1) during the browning operation. This finding was the reverse of what was found for the initial cooking loss. The additional heat of the browning process was severe enough to cause the steam cooked parts to lose the juices they had retained in the previous cooking treatment. Of the parts studied, drums and breasts had the least browning loss, followed by thighs, with wings losing the greatest amount of weight. Wings lost the greatest percentage of their weight in the fryer because they have a higher proportion of skin than the other parts. The skin, which contains a large percentage of fat, was not completely rendered out at the precooking temperatures used, but was cooked out by the severe temperatures of the browning process.

In order to get uniformity of brownness at the three temperatures chosen, it was necessary to employ a different browning time for each temperature. In considering the treatment effects, one must consider the temperature as well as the time involved. Data in Table 1 indicate that percent weight loss was much more for those parts browned at a lower temperature for a longer time than those parts browned at a higher temperature for a shorter time.

Finally, these data were analyzed to determine the total cooking loss that occurred from the raw product to the cooked and browned final product. Final yield was found to be highest for drums and wings, followed by breasts, with thighs having the lowest cooked yield. When total cooking loss was considered, there was no statistical difference ($P < .05$) between the parts browned at 149° C. and 177° C. There was, however, a large advantage to be gained by browning parts at 205° C. After going through the precooking and browning processes, little difference was noted between the two precooking methods used. Water cooking did give 0.6 of a percent better yield, which might become important

TABLE 2.—*Experiment 2—Treatment means for shear values of breast and thighs*[1]

| | Browning temperature | | | |
|---|---|---|---|---|
| | Non-brown[2] | 149°C[3] | 205°C[4] | Avg. |
| Part | | | | |
| *Pectoralis major* | | | | |
| 1st 3 mm. | 10.4[c] | 14.1[e] | 13.8[de] | 12.7[a] |
| 2nd 3 mm. | 9.9[bc] | 12.7[d] | 12.6[d] | 11.7[b] |
| *Iliotibialis* | 8.4[a] | 9.1[ab] | 9.0[ab] | 8.8[c] |
| Average | 9.5[a] | 12.0[b] | 11.8[b] | |

Means within the body of the table and means within each average column or row followed by different letters differ significantly ($P < 0.05$).
[1]Shear value was expressed as kg. of force/g. of meat.
[2]Parts were cooked in water or steam but were not browned in a deep fat fryer.
[3]Parts were browned at 149°C. for 7 minutes.
[4]Parts were browned at 205°C. for 2 minutes.

in a large volume operation if it remained consistent.

In Experiment 2, two cooking methods (water or steam) and two browning temperatures (deep fat frying at 149° C. or 205° C.) were compared to determine their effects on tenderness and rancidity development of broiler breast and thigh parts. The first 3 mm. slice of the *pectoralis major* muscle of the breast was found to be less tender ($P < .05$) than the second 3 mm. slice (Table 2). This finding is in agreement with work performed by other investigators (Wise and Stadelman, 1961; Mickelberry and Stadelman, 1962; Goodwin *et al.*, 1962). Differences observed between the two slices are probably the result of increased dessication of the outer layers during the cooking process or possibly the result of pre-rigor physical abuse given by processing equipment. The *iliotibialis* muscle of the thigh was observed to be more tender than either layer of the *pectoralis major* muscle of the breast.

The comparison of cooking methods in this study indicated that steam cooking produced a more tender product than water cooking ($P < .05$, Table 3). This lower shear value was possibly the result of the protection given the steam cooked parts by the breading applied prior to the cooking process. Because different breading techniques were used for the two different precooking methods, it is impossible to determine whether differences occurred because of the cooking treatment or the breading techniques.

Browning parts in a deep fat fryer was

TABLE 3.—*Experiment 2—Treatment means for TBA numbers of breasts and thighs*[1]

| | Precooking method | | |
|---|---|---|---|
| | Water[2] | Steam[2] | Avg. |
| Browning temperature | | | |
| Non-browned | 2.94[a] | 3.45[b] | 3.20[a] |
| Browned at 149°C., 7 min. | 3.60[c] | 3.58[c] | 3.59[b] |
| Browned at 205°C., 2 min. | 3.18[ab] | 3.13[ab] | 3.15[a] |
| Average | 3.24[a] | 3.39[a] | |

Means within the body of the table and the means within each average column followed by different letters differ significantly ($P > 0.05$).
[1]TBA number is the mg. of malonaldehyde/1000 g. sample.
[2]Water cooked parts were breaded after cooking and steam cooked parts were breaded before.

found to increase shear values ($P < .05$) over a control treatment that was not browned. No difference, however, was observed between parts browned at 149° C. or 205° C. The significance noted in the analysis of variance was attributed to an increase in shear values of breast muscle. Thighs were not found to be affected by browning in a deep fat fryer. This finding suggests that tissue composition, particularly moisture content, may be an important factor in tenderness evaluations.

Both parts ($P < .05$) and browning temperature ($P < .01$) had a pronounced effect on rancidity development. Breast parts subjected to the various treatments of this experiment were found to give lower TBA numbers than thigh parts treated similarly (Table 4). This result was expected since dark meat is known to contain more total lipid than white meat, thus providing the substrate for oxidative deterioration to occur (Peng and Dugan, 1965; Webb, 1969). Red muscle also contains greater quantities of heme compounds, which have been found to be very important catalysts in the oxidation of animal tissue lipids (Marion and Forsythe, 1964). Means presented in Table 4 also indicate that parts browned for two minutes at 205° C. had significantly lower TBA numbers than those parts browned seven minutes at 149° C. This result probably occurred because those parts browned at 149° C. for seven minutes received a more intense internal heat penetration. The intermuscular phospholipid and proteolipid fractions harbor many long chain polyunsaturated fatty acids; thus it might be concluded that the lengthened heat treatment brought about bound lipid hydrolysis that was not achieved by the shorter browning period. Higher TBA numbers might also have resulted because of the greater moisture losses and the larger amount of cooking oil absorbed by the parts browned at 149° C.

Method of precooking resulted in little difference between parts browned at either 149° C. or 205° C. However, in the control group, those parts not subjected to deep fat frying, water cooking resulted in significantly lower TBA numbers than steam cooking. If this much variation in rancidity development occurs as a result of different cooking methods, the commercial producer needs to carefully evaluate his precooking methods.

Analysis of these data produced an interesting part *vs.* browning temperature interaction (Table 4). Breast tissue produced lower TBA numbers than thigh tissue when not browned or when browned at 205° C. However, in the 149° C. treatment the inverse relationship was true. A similar situation was encountered by Webb (1969). This worker found that a great deal of the variation found in TBA numbers was attributable to variation

TABLE 4.—*Experiment 2—Part* vs. *browning temperature interaction for TBA numbers[1] of breast and thigh parts*

| | Part | | |
|---|---|---|---|
| | Breast | Thigh | Average |
| Browning temperature | | | |
| Non-browned | 2.78[a] | 3.61[cd] | 3.20[a] |
| Browned at 149° C.[2] | 3.84[d] | 3.34[c] | 3.59[b] |
| Browned at 205° C.[3] | 3.00[ab] | 3.30[bc] | 3.15[a] |
| Average | 3.21[a] | 3.42[b] | |

Means within the body of the table and means within each average column or row followed by different letters differ significantly ($P < 0.05$).
[1]TBA number is the mg. of malonaldehyde/1000 gm. sample.
[2]Parts were browned at 149°C. for 7 minutes.
[3]Parts were browned at 205°C. for 2 minutes.

in moisture content of the part. An interaction of the nature described might then be explained by considering the inverse relationship of fat and moisture and the higher moisture content of light *vs.* dark meat. Thus, the breast parts were probably more affected, in terms of moisture depletion, than thighs as a result of the extended browning period.

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## NEWS AND NOTES

*(Continued from page 1386)*

3. Thou shalt not abuse the third person passive.
4. Thou shalt not dangle thy participles; neither shalt thou misplace thy modifiers.
5. Thou shalt not commit monotony.
6. Thou shalt not cloud thy message with a miasma of technical jargon.
7. Thou shalt not hide the fruits of thy research beneath excess verbiage; neither shalt thou obscure thy conclusions with vague generalities.
8. Thou shalt not resent helpful advice from thy editors, reviewers and critics.
9. Thou shalt consider also the views of the layman, for this is an insight often unknown to technologists.
10. Thou shalt write and *rewrite* without tiring, for this is the key to improvement.

### CONFERENCE ON RABBIT AND POULTRY RESEARCH

A complete report, 370 pages, of the First French Conference on Rabbit and Poultry Research, held December 12-14, 1974, has been published. The Conference was organized by the Technical Institute of Aviculture (I.T.A.V.I.), the French Branch of the World's Poultry Science Association (W.P.S.A.), and the Poultry Research Station of the National Institute of Agricultural Research (I.N.R.A.).

The report includes 51 presentations, 16 about rabbits and 35 about poultry covering physiology, genetics and behaviour, nutrition, pathology, technology and economy.

The report is for sale by the Technical Institute

*(Continued on page 1414)*