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Approximation of Surface Areas of Cut-Up Chicken and Use in Microbiological Analysis[a]

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ESTABLISHING THE SANITARY quality of poultry products is essential to good processing, handling, and storage. Poultry of good sanitary history and low microbial flora keeps longer in channels of trade and also maintains a good appearance. Low bacterial counts on the surface of dressed poultry are an index of the care and sanitation techniques employed. Furthermore, a low initial bacterial load insures longer keeping time when the product is held iced or in the unfrozen state.

To determine the magnitude of bacterial contamination on the surface of poultry, standardized techniques for making estimates of bacterial numbers are necessary. Such methods give the processor, handler, or researcher useful criteria with which to judge the effectiveness of the techniques he has employed, processing equipment used, or the efficiency of sanitation practices employed. Further usefulness is found in quality control and regulatory work where the efficiency of different washing techniques, potential shelf life of products, the efficiency of in-plant chlorination, or the use of antibiotics on the bacterial flora may be under study.

The growth of bacteria on poultry meat is a surface phenomenon. Unless there has been a puncture, or the interior of the meat contaminated in some mechanical way, poultry meat is of extremely low bacterial count. However, bacteria are found on the exposed surfaces and will grow to enormous populations under proper conditions. It is therefore desirable to develop methods for analyzing the surface of the meat rather than the interior or the entire piece of meat.

Existing methods. Whole dressed poultry presents large areas of intact skin and the sampling of the surface can be done by the use of swabs as described by Ayers *et al. (1)*, Gunderson *et al. (2)* or by Drewniak *et al. (3)*. Such samplings may be made on the breast, back, legs, etc.; bacterial numbers of the various surface areas can then be determined quite easily. On the other hand, when the poultry is cut up and boxed as cut-up, ready-to-cook poultry, a new situation is developed. Cut-up pieces expose areas of raw meat, some skin, bone and cartilage, and present a very irregular surface area. It is difficult to use the swab and template methods *(1, 2, 3)* and relate the bacterial count to the surface sampled.

To overcome this difficulty the method described in U. S. Department of Agriculture *Circular* 930 *(3)* was developed; namely, a "shake" technique in which the piece of chicken to be sampled is placed in a flexible film envelope, sterile water added, and the contents of the envelope or bag shaken. An aliquot of the wash water is then plated in the conventional manner for determining the numbers of bacteria. This method had many advantages—among them the washing of the bacteria from the entire surface area of the piece, ease of making the sampling, the rapidity of the technique, and the non-destructive nature of the sampling.

The major defect of this method was the difficulty of relating bacterial numbers to the surface area from which they came. Due to the extremely irregular surface, a determination of total surface area could not be made, and the bacterial numbers had to be reported per ml. of water used to wash the piece of poultry meat. Some uniformity was obtained by varying the amount of wash water according to the "size" of the piece. But unless bacterial numbers are related to some basic standard of measurement, weight, size or surface area, results mean little except for comparative purposes where nearly identical samples are taken.

Advantages of the proposed method. To correct this lack of knowledge as to the bacterial status of the surface area of each piece of chicken tested, the method presented here was developed. It was reasoned that if the approximate surface area of each piece of meat tested could be determined, then bacterial counts made on different pieces of chicken or at different locations could be compared. Also, this would simplify the reporting of results and provide a more uniform method for use both in research and in plant operations.

After several failures at determining the surface areas of very irregular objects, it was decided to use a wax impression method and from this determine not only the surface area, but the relative change in ratio of weight to surface area as the weight of the birds increased. A wax composed of equal parts of beeswax and resin was found to have many advantages in making wax impressions. Since this formulation gives a product that melts at 140° F. it is not hot enough to damage the meat in any way. Moreover, it is firm and yet plastic at room temperature; it is easily bent with the fingers when removed from the pieces of meat.

METHODS

Individual chicken parts were taken from the refrigerator and weighed to the nearest gram. A small cord was attached to the piece in a position convenient for dipping the part into the wax. The wax was heated to just above the melting point

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and the part quickly lowered into the wax by means of the string. It was immediately withdrawn and held above the wax until a dull appearance indicated solidification of the wax. The dipping was repeated until a layer of wax had been built up of sufficient thickness to be removed from the piece without loss of shape.

The waxed piece of meat was cooled in running tap water, and then the wax was very carefully cut through with a sharp knife to divide the mold into two parts along the greatest dimensions and on the sides of the minimum thickness. The two halves were gently removed and placed on a board with the concave side up. It was found that by making cuts from the edge into the deepest depressions the mold could be flattened out by gentle pressure with the fingers. The small cuts allowed the wax to flatten out without wrinkling or changing shape. This procedure is illustrated in Figure 1. Difficulty in obtaining a good wax impression was encountered only with the two pieces of the back. The inside of the back is very irregular due to the nature of the bone structure and there are many deep cavities from which it was quite difficult to remove the wax without breaking it. However, with the chicken piece quite damp to prevent sticking and allowing the piece to stand at room temperature to increase the plasticity of the wax, the mold could be removed without altering the shape.

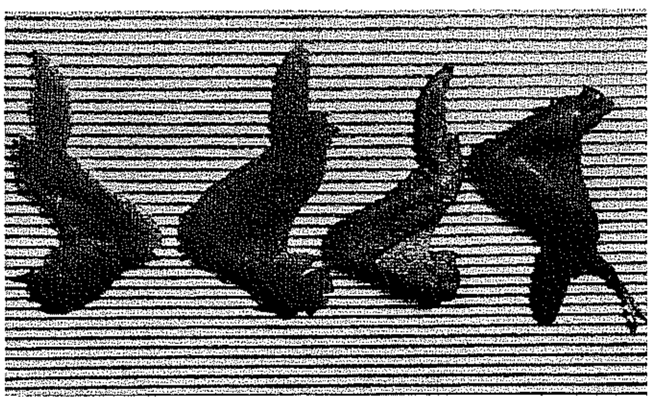

Figure 1. Procedure used to prevent wrinkling; use of small cuts to permit flattening out in making wax impressions.

Measuring. Now that the surface area of the piece of chicken was represented in the flattened parts of the wax mold, the problem became one of measuring that surface. The outline of the pieces of wax was so irregular that the use of a planograph or other type of physical measurement proved impracticable. It was finally decided to determine the surface area by weight. A large sheet of kraft paper was chosen for this purpose. Pieces of this paper were measured and cut into 200 sq. cm. portions and carefully weighed on an analytical balance to determine the uniformity of weight of pieces of equal size from different locations in the piece of paper. The variation was found to be within very narrow limits.

The pieces of wax were laid on the piece of kraft paper and the outline of the wax carefully traced with a pencil following every irregularity of the edge. The paper was then cut along the pencil line to produce a paper pattern of the wax mold. The pattern pieces of each piece of chicken were combined and weighed on the analytical balance. Taking the weights of the previously weighed 200 sq. cm. samples as the standard of weight per sq. cm. of paper, the sq. cm. area of the cut out pieces were calculated.

The above procedure was repeated for each piece of a box of commercial cut-up ready to cook chicken. Each box consisted of 10 pieces: 2 pieces of breast, 2 wings, 2 drumsticks, 2 thighs, the anterior portion of the back, and the posterior portion of the back. These measurements were then repeated for duplicate boxes of commercial cut-up ready to cook chickens for weights between 1¾ pound broilers to 4¼ pound fowl. Twelve birds were used in this series. Since these were boxes from commercial packs, it was believed that they were representative of samples to be found in commercial channels. Some variation might be expected in the exact way in which different plants make the cut in producing ready cut poultry, but these variations should be of minor importance for the purpose of establishing a mean of determining surface areas.

Regression equations for estimating the surface areas of cut up chicken pieces when weight in grams is known are:

Area of breast in sq. cm. = $137.26 + .84 \times$ wt. in grams
Correlation: $R = .94$

Area of wing in sq. cm. = $85.86 + 1.41 \times$ wt. in grams
Correlation: $R = .84$

Area of back in sq. cm. = $94.39 + 1.11 \times$ wt. in grams
Correlation: $R = .93$

Area of thigh and drumstick in sq. cm. = $59.69 + .90 \times$ wt. in grams
Correlation: $R = .94$

Since the square of the correlation coefficient is the proportion of variability in surface area accounted for by its regression on weight, this indicates that except for the wing about 90% of the variability is accounted for. On wing, about 70% of the variability is accounted for.

Confidence bands for predicted values were obtained in accordance with the method of Bennett and Franklin. Because of space limitations, these bands have been omitted.

RESULTS AND DISCUSSION

The results from the weighing of the piece of meat and the surface area obtained from the wax mold were plotted on graph paper. The weight of each piece was plotted against the surface area obtained from the wax mold.

It can be seen from the curves in Figure 2 that

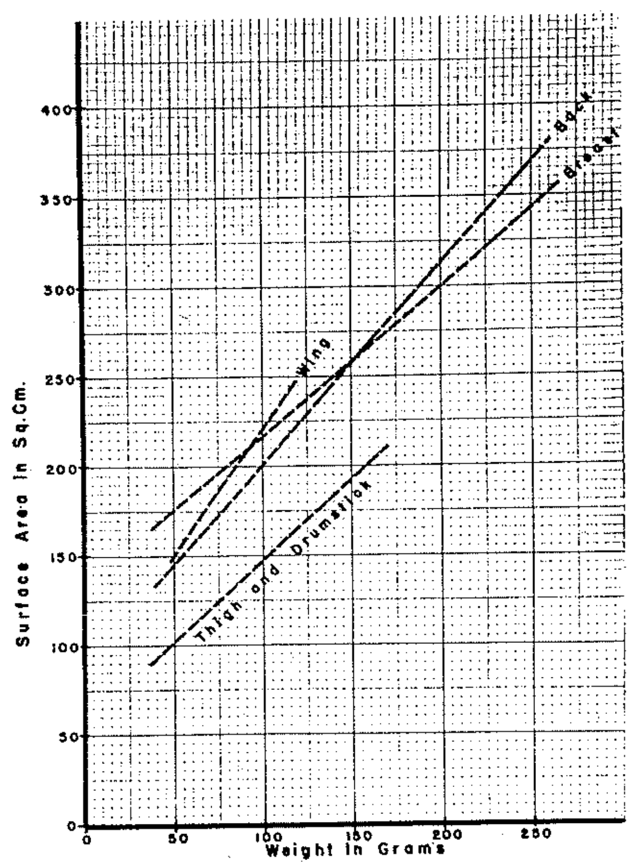

Figure 2. Chart for determining surface area of chicken parts.

there is a linear relationship between the surface area of each type of chicken part and an increase in weight of the piece. The ratio of surface area to weight of piece from small birds to large birds fall along a straight line. The slope of the lines is different for the various parts of chicken. It can be seen that the range in weights for the different size of birds is much greater for the back than for the thigh.

It was found that the posterior part of the back and the anterior part of the back could be superimposed to form a single straight line. This was found true also of the drumstick and the thigh. Accordingly, the curves constructed for Figure 2, are for the back, breast, wing and drumstick—thigh. The horizontal axis represents the weight of the piece of chicken and the vertical axis represents the surface area of the piece. To use the chart the weight of any given piece is found on the horizontal axis and projected upward to the line corresponding to the particular piece. A line is then projected from this point to the vertical axis to determine the corresponding surface area.

As pointed out earlier, the bacterial population of fresh poultry is found almost entirely on the surface and, therefore, bacterial counts should be related in some manner to the surface area sampled. As an example of how Figure 2 may be used for this purpose, the method outlined in USDA Circular 930 *(3)* and in *Recommended Methods for the Microbiological Examination of Foods,* Chapter 14 *(4)*, may be used. If a cut up piece of breast is selected, it should be placed in a sterile plastic bag or jar and approximately 3 times its estimated weight of sterile saline water measured and added. The mouth of the container is then closed and the sample shaken thoroughly. An aliquot of the "wash" water is then removed and plated in several dilutions for bacterial counting. At the conclusion of the incubation period (72 hours at 32° C.) the bacterial count is determined.

After shaking the above sample for making the bacterial count, the piece is removed and blotted to remove surface moisture and weighed to the nearest gram. For ease in presenting this example, let us assume that the piece of breast weighed 200 g. and that 600 ml. of sterile saline water were added. Through the use of Figure 2, it is determined that the approximate surface area of such a piece is 305 sq. cm. The dilution of the sample was 3 parts water to 1 part of sample. Let us further assume that there was an average of 50 bacterial colonies on the plates representitng a dilution of 1 to 10,000. The calculation would then be—

$$\frac{50 \times 10{,}000 \times 3}{305} = 4{,}918.$$

Thus, each sq. cm. of the sample tested is determined to have a bacterial count of approximately 4,920.

If the approximate surface area of the piece had not been available, it would have been necessary to relate the bacterial count to (1) per ml. of dilution water, or (2) per piece of chicken, or (3) per gram of sample. Such counts would have been (1) 500,000 per ml. of dilution water, (2), 1,500,000 for the piece or (3) 7,500 per gram of sample. Since the bacteria found were washed from the surface of the chicken part, relating the count to the surface area is representative of the condition found.

SUMMARY

A method of determining the surface areas of irregular pieces of cut-up chicken of different sizes has been presented. A chart for estimating the surface areas of different types of chicken parts from their known weights has been prepared and a method of relating microbiological results obtained by bacterial techniques to the surface of the sample from which the bacteria came has been demonstrated.

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