

The Determination of Extraneous Water in Frozen Chickens

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Comparative determinations of extraneous water in frozen chickens by different methods of analysis are reported and critically examined. It is shown that the prescribed EEC methods are of little value for enforcement purposes. Of the official methods the Annex III procedure is shown to give the most consistent results, but the calculation is shown to be too generous, since it permits a substantial amount of extraneous water to be undetected. The Stubbs and More procedure is reliable and has some advantage.

A Council Regulation (EEC)¹ laying down common standards for the water content of frozen and deep-frozen chickens, hens and cocks has amongst its aims the establishment of reliable methods for the precise determination of the water content added during processing.

The Regulation requires that regular checks on water uptake in processing shall be made as described in Annex I, describes a rapid check method in Annex II and two referee methods in Annexes III and IV as amended.² It will be demonstrated that the prescribed methods of analysis are neither reliable nor precise. The Regulation does not at the present time apply to poultry treated with polyphosphates.

The check prescribed in Annex I consists of measuring the increase in weight of 20 carcasses from after defeathering and evisceration to the end of the process. It should, therefore, provide a reliable estimate of the water uptake in that part of the process. Great difficulty was found at a local packing station in complying with the maximum tolerance of 5 per cent. prescribed in the Annex. Samples which were drawn for chemical analysis by the procedure in Annex III were found invariably to satisfy the prescribed tolerance and indeed to show little or no apparent extraneous water.

A number of further experiments were carried out in which individual carcasses were each examined following the procedures described in Annexes I, II, III and IV. None of the carcasses contained added polyphosphate.

The rapid detection method in Annex II consists simply of measuring the fluid loss obtained on thawing 20 carcasses. It is stated that if the average loss exceeds 5.2 per cent. it is highly probable that the amount of water absorbed during processing exceeds the limit figure. The Regulation provides that if the loss does not exceed the prescribed level the poultry shall be deemed to comply. If the loss exceeds the limit, or if it is suspected that polyphosphates have been

added, one of the methods of chemical analysis described in Annexes III and IV is to be applied.

Annexe III requires the determination of moisture and nitrogen on seven whole carcasses after maceration. The method assumes a technically unavoidable water absorption during preparation of 7.4 per cent. Allowing for this, and including a confidence interval, the highest permissible level for the average weight of water is stated to be given by the following formula for chickens.

$$W_9 = 3.82 \times RP_A + 59$$

where RP_A is the average weight of protein in the seven carcasses.

In Annexe IV analysis for water and fat is carried out on the flesh separated from each of seven carcasses. The theoretical physiological water content in grammes, including confidence interval is given as

$$(M_5 - M_8 - M_9) \times 3.54 + 27$$

M_5 = weight of flesh

M_8 = weight of water

M_9 = weight of fat

From this and the determined water the extraneous water content is calculated. An average tolerance of 6 per cent. is allowed.

Prior to the publication of these Regulations, meat content was almost invariably determined in the United Kingdom by the so called Stubbs and More³ procedure. A further figure was therefore obtained by this method according to the following formula:

$$\text{Extraneous water} = \left\{ 100 - \frac{N \times 100}{3.70} - F \right\} \frac{\text{Wt flesh}}{\text{Wt carcass}}$$

where N = per cent. nitrogen in flesh

F = per cent. fat in flesh

(using a nitrogen factor⁴ (namely 3.70) recommended by the Analytical Methods Committee of the Society for Analytical Chemistry).

Procedure

Clearly it is not possible to follow precisely the preliminary preparation laid down in each Annex on the same carcass. Hence the following procedure was adopted.

(1) The weight of water uptake was determined in the production establishment following the procedure described in Annex I.

(2) From the 20 test carcasses, seven were taken at random and submitted to the laboratory in a frozen condition.

(3) The weight of drained liquor was obtained following the procedure laid down in Annex II. The liquor being retained.

(4) The drained carcass was then dissected following the procedure laid down in Annex IV.

(5) The separated flesh was combined with the drained liquor from (3) macerated and subjected to a chemical analysis for moisture, fat and protein.

TABLE I
ESTIMATION OF APPARENT EXTRANEOUS WATER IN CHICKEN CARCASSES BY VARIOUS METHODS

Sample No.	Weight grammes	Annex I Weight Gain (A) per cent.	Annex II Drip (B) per cent.	Annex II error (C)	Annex III per cent.	Annex III error	Annex IV per cent.	Annex IV error	Stubbs and More per cent.	Stubbs and More error
4-1	1568	5.0	3.3	-1.7	0.7	-4.3	-0.8	-5.8	5.8	+0.8
4-2	1742	5.9	2.0	-3.9	2.1	-3.8	1.1	-4.8	4.9	-1.0
4-7	1619	3.5	2.3	-1.2	-2.6	-6.1	-0.7	-4.2	2.5	+2.5
4-9	1437	6.6	3.6	-3.0	5.0	-1.6	2.3	-4.3	9.1	+1.7
4-12	1731	6.1	3.5	-2.6	4.1	-2.0	2.9	-3.2	7.8	+0.8
4-15	1356	6.0	3.2	-2.8	-1.7	-7.7	1.2	-4.8	6.8	+0.3
4-25	1497	5.8	3.8	-3.0	-0.8	-6.6	-5.9	-11.7	6.1	-3.1
5-3	1392	9.6	4.5	-5.1	0.3	-9.3	0.6	-9.0	6.5	+0.9
5-8	1819	5.0	2.5	-2.5	0.8	-4.2	-3.7	-8.7	5.9	+2.0
5-11	1385	6.2	3.2	-3.0	2.1	-4.1	-1.5	-7.7	8.2	-0.6
5-17	1320	7.7	4.6	-3.1	0.8	-6.9	-2.9	-10.6	7.1	-1.3
5-20	1280	6.1	3.1	-3.0	-2.3	-8.4	-7.3	-13.4	4.8	+0.9
5-23	1534	5.0	2.0	-3.0	-1.7	-6.7	-10.4	-15.4	5.9	+3.1
5-25	1543	9.4	5.3	-4.1	2.1	-7.3	-3.1	-12.5	6.3	+2.9
6-1	1349	3.9	3.0	-0.9	2.9	-1.0	2.3	-1.6	6.8	+1.4
6-4	1536	9.1	5.1	-4.0	5.4	-3.7	3.5	-5.6	10.5	+1.8
6-5	1049	6.5	5.2	-1.3	3.6	-2.9	4.3	-2.2	9.6	-0.7
6-15	1066	5.8	4.0	-1.8	1.9	-3.9	4.1	-1.7	7.6	+2.8
6-20	1512	4.6	3.5	-1.1	-1.0	-5.6	-6.7	-11.3	3.9	+0.2
6-23	1511	3.9	3.0	-0.9	2.9	-1.0	2.2	-1.7	6.7	+2.3
6-24	1720	5.4	3.1	-2.3	-0.3	-5.7	-6.7	-12.1	5.2	-0.3
7-4	1578	5.0	2.2	-2.8	2.1	-2.9	-0.6	-5.6	7.3	+3.5
7-7	1795	6.8	2.3	-4.5	-2.9	-9.7	-5.8	-12.6	3.5	-0.3
7-10	1941	6.3	2.8	-3.5	1.6	-4.7	-1.5	-4.8	6.0	-1.6
7-13	1269	8.3	4.6	-3.7	1.1	-7.2	4.5	-3.8	6.7	-3.4
7-16	1740	14.5	5.5	-9.0	7.6	-6.9	6.1	-8.4	11.1	-0.2
7-20	2076	14.0	5.2	-8.8	9.7	-4.3	3.5	-10.5	13.8	+3.2
7-24	1438	3.7	2.1	-1.6	0.4	-3.3	-0.3	-4.0	6.9	+1.2
8-2	1325	8.2	4.6	-3.6	1.8	-6.4	-5.4	-13.6	9.4	-2.3
8-3	1637	8.5	3.6	-4.9	1.5	-7.0	3.3	-5.2	6.2	+5.8
8-11	1197	7.0	4.2	-2.8	8.3	+1.3	5.9	-1.1	12.8	+7.4
8-12	1384	5.9	3.9	-2.0	6.1	+0.2	-4.6	-10.5	13.3	+1.0
8-17	1497	7.3	4.7	-2.6	2.6	-4.7	3.2	-4.1	8.3	+1.6
8-18	1790	4.9	2.1	-2.8	2.1	-2.8	1.4	-3.5	6.5	+1.7
8-25	1196	11.0	6.4	-4.6	5.8	-5.2	5.9	-5.1	12.7	0.7
Mean				-3.2		-4.8		-7.0		2.4
Standard deviation				1.8		2.6		4.1		0.9
Standard error (sample of seven carcasses)				0.7		1.0		1.5		

Column C is derived by deducting B from A.

The separated skeleton was ground and also subjected to analysis for moisture, fat and protein.

(6) The results of analysis on the combined flesh and drained liquor were calculated to give the extraneous water content using the formula provided in Annex IV. From the same analysis the total meat content was calculated using the Stubbs and More procedure and the extraneous water obtained according to the formula given above.

(7) The results of analysis of the flesh and drained liquor mixture and the bones were combined together in proportion to the weights of flesh and bones to give the analysis of the whole carcass. The extraneous water was calculated from the figures so derived by the formula in Annex III. In order, however, to make this strictly comparable with the results obtained in the other procedures the figure so obtained was expressed as a percentage and the tolerance of 7.4 per cent., which is allowed for in the calculation, was added to the figures so obtained.

Results

The results of all these analyses given in terms of percentage of extraneous water are shown in Table I. For the purpose of this table it is assumed that the weight gain obtained by the Annex I procedure is a true estimate of the extraneous water. It is clearly an underestimate as will be discussed later. The column against each procedure shown as error is the simple difference between the result obtained and that found in Annex I.

Table II illustrates the effect of taking the mean results for the seven carcasses comprising the sample taken on each occasion. It demonstrates that whilst the Annex I check procedure indicates a failure to meet the required standard, the results of chemical analysis by Annex III or IV easily satisfy the standards prescribed in those Annexes. Indeed, it is our experience that it is most unlikely that even the most unsatisfactory output from the processing plant would be condemned by either Annex III or IV.

TABLE II
PERCENTAGE OF EXTRANEEOUS WATER IN CHICKEN CARCASSES
(MEANS OF SEVEN DETERMINATIONS BY VARIOUS METHODS)

Sample No.	Annex I	Annex II	Annex III	Annex IV	Stubbs and More
4	5.6	3.1	1.0	0	6.1
5	7.0	3.6	0.3	-4.0	6.4
6	5.6	3.8	2.2	0.4	7.2
7	8.4	3.5	2.8	0.8	7.9
8	7.5	4.2	4.0	1.4	9.9

Units are per cent. extraneous water.

Discussion

Clearly no useful purpose can be served by enforcement Authorities using the present procedures in Annex III or IV for the detection of extraneous water. A study of the results reported in Table I may indicate whether some improved

procedure can be devised, or whether the natural variation in the parameters determined by chemical analysis is such that no better system is possible.

It is suggested that the standard deviations of the error figures in Table I are a measure of how consistent the various methods may be. The simple Annex II procedure shows the lowest standard deviation. Annex IV shows a significantly higher figure than both Annex III and Stubbs and More which are not significantly different. It is interesting to note that in Annex IV the physiological water is obtained as a function of the dry non-fat solids of the flesh and that this figure is derived by difference, an unsatisfactory procedure increasing the possibility of error. This method is clearly less reliable and must be considered unsatisfactory. Annex III, based on analysis of the whole carcass, and Stubbs and More on the analysis of the flesh alone show substantially the same range of error indicating that the separation of the flesh is not a factor.

In considering the figures for mean error it must be remembered that the Annex I results do not take account of water absorbed in the defeathering process. There appears to be little reliable information on the amount of water uptake in this stage. However, the maximum water absorption for dry chilled poultry is given as 2 per cent. in Annex II, 2.9 per cent. in Annex III and 2.3 per cent. in Annex IV. Assuming that this occurs in defeathering it is suggested that the mean water uptake in this process might be assessed as approximately 1.5 per cent. If this figure is accepted the overall mean errors for the four methods of analysis are as follows:

Annex II	Annex III	Annex IV	Stubbs and More
-4.7	-6.3	-8.5	-0.8

The reason for the failure to confirm excess extraneous water by chemical analysis is apparent. Clearly the calculations and tolerances in the official methods are too generous. It must be remembered that the calculations in Annexes III and IV incorporate a confidence interval.

Consideration of the data obtained from these experiments leads to the following conclusions.

Annex II

The mean error for this procedure of nearly 5 per cent. means that any carcass showing measurable drip must be suspect. This test seriously underestimates the extraneous water. It is misleading and should be discarded.

Annex III

The overall mean error is minus 6.3 per cent. and with a standard error for seven carcasses of only 1.0, this could clearly be reduced. The data on which the formulae are based should be checked and re-examined. Nevertheless, even after revision it appears likely that true extraneous water contents of over 10 per cent. may not always be detected.

Annex IV

The wide range of error obtained by this method makes it unsatisfactory and it should be rejected.

Stubbs and More

This method provides results as consistent as those obtained by Annex III. The low figure for mean error gives excellent confirmation of the nitrogen factor recommended by the Society for Analytical Chemistry. It has the additional advantage that since the flesh is separated from the bone the determination of added polyphosphates is simplified. The presence of ground bone is a complication if this test is applied to a carcass prepared under Annex III. The Regulation does not at present apply to polyphosphate treated poultry, but it is nevertheless necessary to establish its absence.

The method gives a similar confidence level to Annex III. It is unlikely that this can be improved upon in any method employing proximate analysis due to the natural variations in the parameters on which the calculations are based.

This paper illustrates the pitfalls which may arise in prescribing methods of analysis in legislation. A more satisfactory procedure is to allow the expert analyst freedom of choice remembering that he must justify his results in the Courts.

From the results reported here the Annex III and Stubbs and More procedures show the most consistent results. Clearly the factors and confidence interval in the Annex III calculation are much too generous, but, bearing in mind the limited number of results reported and the assumption regarding the water uptake in defeathering, it would be unwise to suggest amended factors. No confidence interval has been incorporated in the Stubbs and More results and yet no injustice would occur from their use.

References

1. Official Journal of the European Communities L 339 8th December 1976 Regulation No. 2967/76.
2. *Ibid.* L 270 15th October 1980 Regulation No. 2632/80.
3. Stubbs, G., and More, A., *Analyst* 1919, **44**, 125.
4. Analytical Methods Committee, *Analyst*, 1963, **88**, 583.