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Cooking the Christmas Turkey

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50°C
THERMOMETER
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150
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Cooking the Christmas Turkey

Consumers have often found that following previous recommended cooking times for turkeys resulted in birds with dry and unappetising meat. To determine the optimum cooking time to produce a safe and succulent bird in fan-assisted ovens, ***safe*food** commissioned scientific research incorporating cooking trials, sensory quality trials and microbiological challenge tests on stuffed and unstuffed turkeys.

Cooking trials

A number of stuffed and unstuffed turkeys were roasted in fan-assisted ovens. The temperature rises during the cooking process were measured in a number of points in the birds to identify when the cooking temperature reached the point that would kill any dangerous bacteria present. These time-temperature data gave the cooking times required to assure safe cooking and enabled mathematical equations to be derived giving cooking time instructions according to turkey weight. These equations only apply to turkeys cooked in fan-assisted electric ovens.

This research showed that the thickest parts of the breast and thigh meat were the slowest parts of the turkey to cook. In cavity stuffed turkeys the centre of the stuffing was the slowest point to cook.

Sensory trials

Expert sensory panels were used to identify the length of time for which cavity stuffed turkeys should be roasted in order to get the best taste. Cavity stuffed turkeys cooked according to the cooking time instructions developed from the cooking trials gave sensory evaluation scores of 6 and 7. These scores indicate that the cooking instructions produced fairly good to good quality turkey meat according to its appearance, flavour and texture. The equivalent sensory scores for unstuffed turkeys were between 6 and 8 indicating similar quality turkey meat to the cavity stuffed birds.

Microbiological challenge tests

Microbiological challenge tests were undertaken to provide an extra check that the cooking instructions produced cooked turkey that was microbiologically safe. This was preformed by adding a cocktail of five strains of *Salmonella* and *Campylobacter* to test turkeys. After cooking, using the cooking times developed in the cooking trials studies, no surviving microorganisms were recovered from any of the birds, either stuffed or unstuffed. This proved that the cooking instructions produced microbiologically safe turkey.

Overall the cooking instructions developed from the project produced microbiologically safe turkeys of fairly good to good sensory quality. The results from this project provide cooking advice for fan-assisted ovens based on sound science and is the basis for recommendations which will help ensure that every turkey (large or small), is cooked sufficiently.

Recommendations for consumers

1. **Make sure that the turkey is thoroughly defrosted in the fridge before cooking.** If it is not defrosted it will not cook properly and safely. Once thoroughly defrosted, a previously frozen turkey cooks in the same way as a fresh turkey.

2. **Consider cooking the stuffing outside the bird, as this will produce a tastier turkey.** Stuffed turkeys can take a lot longer to cook than unstuffed turkeys. For example, a large (7.5kg) turkey with cavity stuffing takes 30% longer (almost 1½ hours longer) to be properly and safely cooked, than a similar size unstuffed bird. Such longer cooking times can impair the quality of the turkey meat.

3. **If you are stuffing the turkey, use no more than 10% of the weight of the unstuffed bird.** If you add too much stuffing, you will need to cook the turkey for longer, and this will affect the quality of the meat. The weight of the stuffing should be no greater than 10% of the weight of the unstuffed bird.

4. **Calculate the cooking time based on the weight of your stuffed bird.** To calculate the correct cooking time for your turkey, make sure to use the combined weight of the total oven-ready bird, including the weight of the added stuffing.

5. **To calculate the cooking time:**
(for all birds heavier than 3.3kg, in a fan-assisted oven)

Unstuffed turkey

1. Preheat the oven to 180°C.
2. Cook the bird at 180°C for 19 minutes per kg + 124 minutes.

Stuffed turkey

1. Preheat the oven to 180°C.
2. Cook the bird at 180°C for 28 minutes per kg + 108 minutes.

6. **The performance of different fan-assisted ovens may vary,** so it is important to check the manufacturer's handbook to ensure safe and optimum performance.

7. **Check that you fully understand and have properly adjusted oven controls** to achieve the required cooking temperatures. Even when ovens are correctly adjusted, the presence of other items in the oven, or frequent opening and closing of the oven door can make the oven less effective and extra cooking time will be needed.

8. **Cover the bird with tinfoil during cooking and baste every hour.** The use of tinfoil helps cook the bird more evenly and gives a more "juicy" product. The turkey should be basted every hour during cooking (the tinfoil can be removed for the last half hour to brown the skin).

9. **Don't rush to carve the stuffed cooked bird!**
One way of making sure that the stuffing is properly cooked, without risking overcooking the meat, is to remove the turkey from the oven when the meat is fully cooked, and leave it to rest for half an hour covered in tinfoil at room temperature, before carving.
The stuffing continues to cook inside the hot bird during this time, but the meat is not being overcooked.

10. **Double-check that your turkey is fully cooked using the following tests;** pierce the thickest part of the thigh and breast meat with a clean fork or skewer and check that

- there is no pink meat left
- the juices run clear
- it is piping hot all the way through.

If the bird is stuffed, check that the centre of the stuffing is piping hot before serving.


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Introduction

This study, carried out during 2007 and 2008, aimed to identify the optimum conditions for cooking turkeys, both stuffed and unstuffed. It provides scientifically-based preparation and cooking instructions which consistently deliver a turkey that is microbiologically safe and of acceptable sensory quality. The stuffed turkeys were prepared by stuffing either the cavity or the neck-flap of the bird and two different types of stuffing were used: breadcrumb and sausage-meat.

The study achieved this aim by collecting and combining data on the:

- patterns of temperature changes at different points within stuffed and unstuffed turkey carcasses during cooking
- time taken to achieve a temperature high enough to make turkey and stuffing microbiologically safe (72°C)
- effects of the cooking on the viability of *Salmonella* and *Campylobacter*
- sensory quality of the cooked products.

The study focused on fan-assisted ovens, the most widely-used oven type, but also examined the safety and quality of products cooked in conventional electric, gas and range type ovens. Turkeys of three weight categories (i.e. small ≈3.3kg, medium ≈5.5 kg, and large ≈7.5 kg) were prepared, stuffed and cooked as described below.

Experimental procedures

This study was commissioned by ***safe*food** and carried out by Campden & Chorleywood Food Research Association (UK). The procedures used are summarised below.

Cook time determinations

2007 studies

Time/temperature cooking data was determined for turkeys of three weight categories (≈3.3kg, ≈5.5kg and ≈7.5kg). These data sets were collected on four separate occasions for cavity-stuffed turkeys, three separate occasions for neck flap-stuffed turkeys and once for unstuffed turkeys. Four identical calibrated fan-assisted ovens (pre-

heated to 180°C) were used for the cooking trials. The birds, which had been previously frozen, were fully thawed and maintained at a temperature of ≤5°C until cooking. Immediately before cooking, the birds were stuffed in the cavity or in the neck flap, with a breadcrumb stuffing equal to 10% of the total unstuffed thawed turkey carcass weight. The breadcrumb stuffing recipe used is in Appendix 1.

Ten calibrated thermocouple probes were used to measure the temperature of each bird, and these temperatures were recorded every five seconds during the cooking process.

- In the stuffed birds probes were placed in the breast and thigh (both left and right sides) and in the stuffing
- In unstuffed birds, probes were placed in the breast and thigh (both left and right sides), inside the cavity and on the top surface of the bird, just under the skin.

Each bird was placed breast-up in a roasting tray and cooked in the centre of an oven (pre-heated to 180°C). The birds were lightly seasoned with salt and pepper, coated with approximately 10g of butter and basted every hour during cooking. To reduce dehydration, the turkeys were covered in aluminium foil during roasting; this was kept in place throughout cooking. The cooking time used was determined as the time to achieve a minimum temperature of 72°C in the slowest heating point in the bird or the stuffing.

2008 studies

Four separate sets of time/temperature data were collected for cooking turkeys in the three weight categories (as above) both stuffed and unstuffed. Four identical calibrated fan-assisted ovens (pre-heated to 180°C) were used for the cooking trials. The birds, which had been previously frozen, were fully thawed and maintained at a temperature of ≤5°C until cooking. The birds were stuffed (immediately prior to cooking) in the cavity with a sausage-meat stuffing, equal to 10% of the total unstuffed thawed turkey carcass weight. The sausage-meat stuffing recipe used is in Appendix 2.

Thermocouples were placed in each bird as described previously to measure the temperature during cooking. Each bird was placed breast-up on a roasting tray, seasoned with salt and pepper, coated with 10g butter, covered in foil and basted every hour during cooking. Time/temperature data were recorded every five seconds at ten locations using thermocouple probes as described previously.

Determination of mathematical equation to express cooking time

A single straight line instruction (based on Y= mX + C) was devised with the cooking time determined based on the weight of the turkey and stuffing, where Y is the overall cooking time (minutes), m is the number of minutes per kg, X is weight of bird and C is a constant time (minutes).

Sensory evaluation

The aim of this part of the study was to obtain data on the sensory quality of the cooked poultry. Birds of each weight category were cooked according to the above instruction for sensory evaluation. A check was made at the end of the cooking period to ensure that the slowest heating point had reached 72°C.

Three experienced assessors were involved and each assessor independently described the:

- External appearance of the whole bird
- Internal muscle tissue appearance (white meat and dark meat)
- Flavour
- Texture and mouth-feel (white and dark meat).

The panel consensus scores were calculated to provide an overall quality score for each bird according to a scale from 1 to 9 as given below:

9	Excellent quality
8	Very good quality
7	Good quality
6	Fairly good quality
5	Satisfactory quality
4	Just acceptable quality
3	Poor quality
2	Very poor quality
1	Bad quality

The data obtained in the 2007 study (cavity-stuffed (breadcrumb) turkeys) were analysed with the 2008 data (cavity-stuffed (sausage-meat) turkeys).

Microbiological challenge tests

The aim of the microbiological study was to obtain practical data to verify that the derived turkey cooking times inactivated target microorganisms using inoculation studies. The raw turkey was inoculated with a known concentration of foodborne pathogens, i.e. a cocktail of five *Salmonella* strains (S. Heidelberg, two S. Typhimurium DT104, S. Bronx, and S. Hadar all isolated from fresh poultry) and five *Campylobacter* strains (three *C. jejuni, C. coli* and *C. lari,* all isolated from foods) of known heat-resistance characteristics. Microbiological reduction data was obtained using the optimum cooking conditions for the three turkey weight categories (i.e. small ≈3.3kg, medium ≈5.5 kg, and large ≈7.5 kg). These experiments were repeated on three separate occasions. The detailed experimental procedure is described in Appendix 3.

Oven comparison

Time/temperature cooking data sets were also obtained for identically prepared turkeys of the three weight categories during cooking in a gas oven, a non-fan assisted electric oven and a range-type oven, each of which had been calibrated and equilibrated to 180°C, prior to cooking a stuffed turkey.


5kg
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1lb
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1kg
8
3
7
4
6
5
3
2

Results and Discussions

Cook Time Determinations

The data from the thermocouples used to measure the turkey and stuffing temperatures during the cooking process were examined. From these data the heating times for the turkeys and stuffing to reach a temperature of 72°C was determined. The time/temperature cooking data for cavity stuffed (breadcrumb) turkeys collected in the study conducted in 2007 are presented in Table 1. Table 2 presents the cooking time/temperature data for the cavity stuffed (sausage meat) turkeys collected in the 2008 study.

Table 1 Temperature data obtained from turkeys stuffed in the cavity with breadcrumb stuffing (2007)

Weight (kg)	Run	Stuffed Turkey Weight (kg)	Measured time to cook to 72°C (minutes)
Low (≈3.3)	1	3.27	168
	2	3.30	183
	3	3.27	170
	4	3.22	177
Medium (≈5.5)	1	5.01	234
	2	5.12	249
	3	5.38	246
	4	5.16	246
High (≈7.5)	1	8.62	332
	2	8.95	324
	3	8.55	329
	4	8.47	326

Table 2 Temperature data obtained from cavity-stuffed turkeys using sausage-meat stuffing (2008)

Weight (kg)	Run	Stuffed Turkey Weight (kg)	Measured time to cook to 72°C (minutes)
Low (≈3.3)	1	3.36	178
	2	4.40	213
	3	3.90	195
	4	3.54	202
Medium (≈5.5)	1	4.89	232
	2	5.01	222
	3	4.92	228
	4	5.19	232
High (≈7.5)	1	6.86	281
	2	6.65	262
	3	6.68	281
	4	6.70	279

After statistical analysis, there was no significant difference found between these two sets of data (Table 1 and 2). These data were found to follow a straight-line relationship (2007: R^2=98% and 2008: R^2=97%) for cooking time against bird weight.

Hence, the data in Table 1 and 2 were pooled and the cooking time was expressed by the equation, Y = mX + C (the equation for a straight line) where: Y = total cooking time, m = bird weight, X = number of minutes per kg and C is a constant (measured in minutes).

Using a linear regression to calculate the required Y = mX + C gave a cooking time/bird weight relationship (Figure 1) expected to deliver at least 72°C in 95% of cases (the 95% Prediction Interval [PI]).

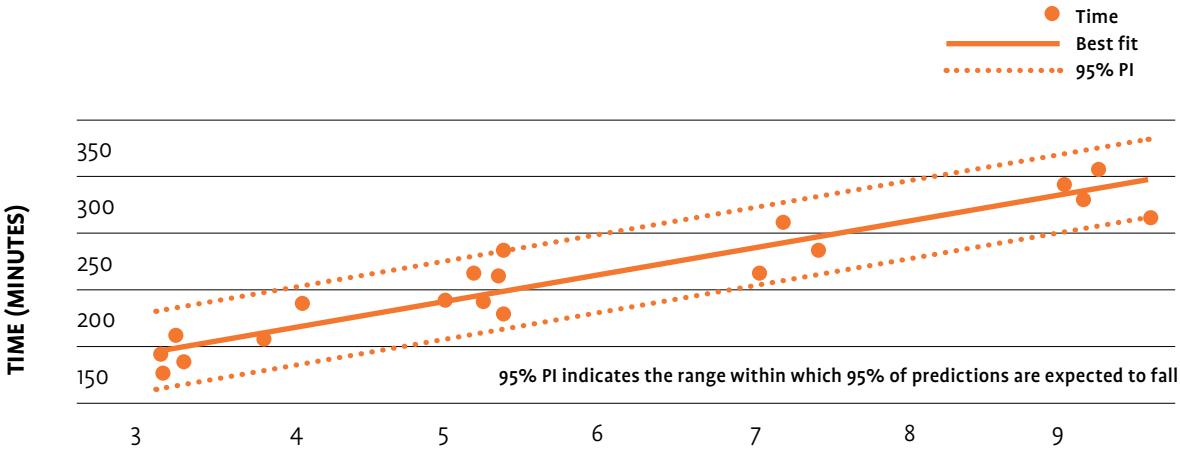

Figure 1 Determination of cavity-stuffed turkey instructions based on cook times to 72°C. (Best fit: time to 72°C= 90.9 + 27.7 weight; Upper PI approximately: time to 72°C= 108 + 27.8 weight; Regression R^2 =97%)

The 95% PI data indicates that the cooking time for foil-covered, cavity-stuffed turkeys cooked in a pre-heated, fan-assisted oven at 180°C may be calculated from the expression:

Cooking time (minutes) = 27.8 (minutes) x stuffed turkey weight (kg) plus 108 minutes

The data for neck-stuffed turkeys (2007) are presented in Appendix 4. These data have not been used further in the prediction of overall cooking instructions for all turkey weights categories investigated of neck-stuffed birds as the dataset was insufficient. The equivalent data for unstuffed turkeys are given in Tables 3 and 4.

Table 3 Temperature data obtained with unstuffed turkeys (2007)

Weight (kg)	Run	Stuffed Turkey Weight (kg)	Measured time to reach to 72°C (minutes)
Low (≈3.3)	1	3.11	145
Medium (≈5.5)	1	6.09	198
High (≈7.5)	1	7.70	221

Table 4 Temperature data obtained with unstuffed turkeys (2008)

Weight (kg)	Run	Stuffed Turkey Weight (kg)	Measured time to reach to 72°C (minutes)
Low (≈3.3)	1	3.30	156
	2	3.12	142
	3	3.31	157
	4	3.22	171
Medium (≈5.5)	1	5.34	208
	2	5.22	201
	3	5.46	231
	4	5.39	211
High (≈7.5)	1	7.89	261
	2	7.84	244
	3	7.46	204
	4	7.64	252

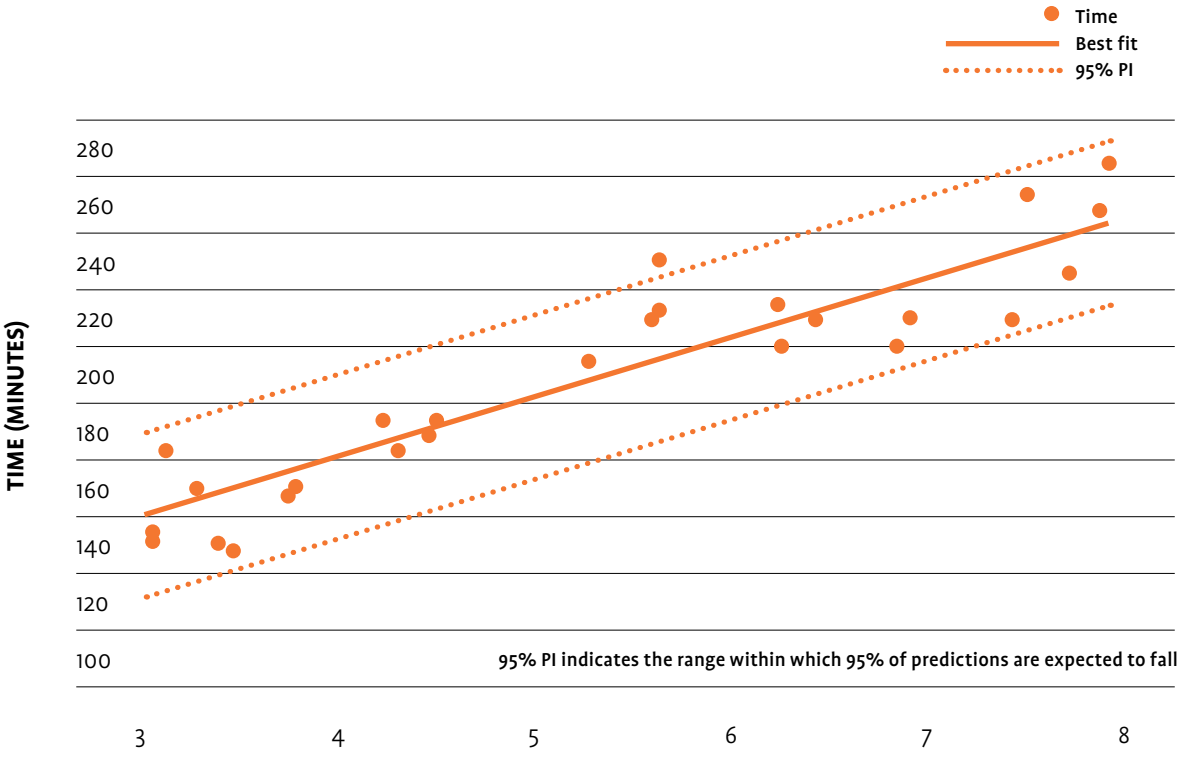

Figure 2 Determination of unstuffed turkey instructions based on cook times to 72°C. (Best fit: time to 72°C= 91.6 + 18.9 weight; Upper PI approximately: time to 72°C= 124 + 27.8 weight; Regression R^2 =97%)

The same linear regression approach was taken with the data obtained for unstuffed birds. In total, three trials were conducted in 2007 and 2008 (two conducted by CCFRA for ***safefood*** and one for a related study funded by the UK Food Standards Agency). ***safefood*** would like to acknowledge the Food Standards Agency's consent to incorporate their data into this analysis. The results are presented in Figure 2.

The 95% PI data indicated that for foil-covered, unstuffed turkeys cooked in a pre-heated, fan-assisted oven at 180°C the cooking time may be calculated from the expression:

Cooking time (minutes) = 19.0 (minutes) x unstuffed turkey weight (kg) plus 124 minutes

Table 5 Sensory evaluation scores for cavity stuffed turkeys with sausage-meat stuffing (2008)

Stuffed Turkey Weight	Cooking Time (minutes)	Sensory Score (1 – 9)
3.99 kg	27.8 per kg + 108 = 219	7
4.96 kg	27.8 per kg + 108 = 246	6
7.09 kg	27.8 per kg + 108 = 305	6

Sensory trials

The equation for cavity stuffed turkeys was used to cook one turkey from each weight range in the 2008 study (sausage-meat stuffed) and these were assessed for their sensory quality.

The sensory characteristics of all three weight categories of turkey were similar but the smallest turkey gave a slightly higher grade (Table 5).

For comparison the sensory scores for cavity-stuffed birds using breadcrumb stuffing (2007) are given in Table 6. Although the cooking times in the original 2007 study were not exactly as described by the linear cooking instruction, the data give an indication of the likely cooked turkey quality. These results indicate similar scores for the turkeys cooked in the 2007 study compared with the results in Table 5.

Table 6 Sensory evaluation scores for cavity-stuffed turkeys using breadcrumb stuffing (2007)

Stuffed Turkey Weight	Cooking time (minutes) from linear equation	Cooking time (minutes) used (2007)	Sensory score (1-9)
3.32 kg	27.8 per kg + 108 = 200	55 per kg + 20= 203	6
5.44 kg	27.8 per kg + 108 = 259	45 per kg + 20 + 265	7
8.92 kg	27.8 per kg + 108 + 356	50 per kg + 20= 377	6

The cooking times suggested by the linear equation were shorter than the cooking times developed in the 2007 study. Since the main problem with cavity-stuffed turkeys is dehydration arising from the extended heating time required for full cooking of the stuffing, it would be expected that the linear equation for birds from all weight categories would give slightly better eating quality than the non-linear cooking equations developed in 2007. The equivalent sensory scores for unstuffed turkeys were 6 – 8 indicating results similar to those of the cavity-stuffed birds. (The sensory evaluation scores for neck-stuffed birds are given in Appendix 5).

Microbiological challenge tests

The initial concentration of cells in each glass ampoule was determined to be 2.0 x 10^7 cfu per ml for *Salmonella* inoculated into turkey homogenate. The initial concentration per glass ampoule for *Campylobacter* cells resuspended in turkey homogenate was 1.1 x 10^7 cfu per ml.

After cooking no surviving *Salmonella* or *Campylobacter* cells were recovered from all samples taken from either the stuffed or unstuffed birds, in all of the weight categories. The detection limit for the plate count procedure was <5 cfu when plating surviving cells on the non-selective agar and <10 cfu when plating surviving cells on selective media. In addition, no surviving *Salmonella* or *Campylobacter* cells were detected after using enrichment procedures, which are designed for the detection of injured and low numbers of surviving cells.

Hence, the cooking instructions developed were appropriate to produce turkey which would be microbiologically safe in relation to contaminating *Salmonella* and *Campylobacter* present at concentrations up to 1.0 x 107 cfu per ml.

Oven comparison

This oven comparison study was carried out in 2007, and the results obtained indicated that the recommendations developed for cooking turkeys in fan-assisted electric ovens are not suitable for use in other oven types.

The application of the cooking instruction equation given above with these alternative oven types led to under or overcooking as follows.

- In the non-fan assisted electric oven
  The small (≈3.3kg) and large (≈7.5kg) stuffed turkeys did not achieve the minimum safe cooking temperature of 72°C, i.e. the coolest part of the small stuffed turkey only reached 68°C and the coolest part of the large stuffed turkey only reached 67°C.
- In the gas oven
  No turkey in any of the weight categories achieved a minimum temperature of 72°C, i.e. the coolest part of the small stuffed turkey only reached 57°C, the coolest part of the medium (≈5.5kg) stuffed turkey only reached 60°C, and the coolest part of the large stuffed turkey only reached 52°C.

- In the range (AGA type) oven

  The oven temperature profile indicated that the centre of the oven was considerable higher than the set temperature (180°C). The centre temperature continued to increase for an hour during the period that the temperature was monitored, peaking at approximately 250°C. Thus, the application of the above cooking time equation would have led to considerable overcooking of all three weight categories of stuffed turkeys.

Overall, the above results indicate that the recommendations developed in this study for the cooking of stuffed and unstuffed turkeys in fan-assisted oven (180°C) should not be used for turkeys cooked in conventional gas, non-fan assisted electric or range type ovens.

Conclusions

1. The time-temperature cooking data, *in fan-assisted electric ovens*, for stuffed turkeys (cavity) or unstuffed turkeys determined the times to cook to an internal temperature of 72°C. These data enabled mathematical equations to be derived as given below:

   - For stuffed birds (cavity) in all weight categories (including stuffing) a single equation could be applied:

     Cooking time (minutes) = 28 (minutes) x stuffed turkey weight (kg) plus 108 minutes

   - For unstuffed birds in all weight categories a single equation could be applied:

     Cooking time (minutes) = 19.0 (minutes) x unstuffed turkey weight (in kg) plus 124 minutes

2. Turkeys cooked according to the above instructions gave sensory evaluation scores of 6 and 7 on a 9 point scale. These are defined as fairly good quality and good quality, respectively, indicating that the cooking instructions produced at least fairly good quality product across the parameters assessed of appearance (external and internal appearance of the white and dark meat), flavour and texture.

3. Microbiological challenge tests were undertaken to ensure that the cooking instructions produced cooked turkeys that were microbiologically safe. A cocktail of five strains of *Salmonella* and *Campylobacter* were used. After cooking no surviving microorganisms were recovered from any of the birds, either stuffed or unstuffed, indicating that the cooking instructions produced microbiologically safe turkey.

4. Overall the cooking instructions developed produced microbiologically safe turkey of more than acceptable sensory quality.

Appendices

Appendix 1

Composition of breadcrumb stuffing

500g white breadcrumbs

50g butter

1 onion, grated or finely chopped

4 sage leaves, finely chopped

Melt the butter in a pan, add the onion and cook until soft. Add the chopped sage and fold in the breadcrumbs, season with salt and pepper.

Appendix 2

Composition of sausage-meat stuffing

900g good quality pork sausage-meat

1 level tablespoon dried sage

1 large onion, grated or finely chopped

4 heaped tablespoons white breadcrumbs

1 egg, beaten

2 tablespoons cold water

Add breadcrumbs to the onion and sage in a large mixing bowl, add the water and mix thoroughly. To this add the sausage-meat and egg and mix well. Use straight away or store below 5°C for no more than 3 days.

Appendix 3

Microbiological challenge tests

The experimental approach for the microbiological challenge tests involved the inoculation of a turkey homogenate with known quantities of the *Salmonella* or *Campylobacter* cells and transferring these to specifically designed glass ampoules. The ampoules were placed in specific locations in the birds during

cooking to fully assess the effects of the cooking on microbial viability.

Each of the selected optimum heating times (determined from the sensory evaluation studies) was tested using one bird from each weight category for cavity-stuffed, neck-stuffed and unstuffed birds (9 birds in total).

Salmonella studies

Ampoules containing the *Salmonella* inoculated turkey homogenate were inserted into the raw birds in four locations, a minimum of 1 cm into the flesh or 2 cm into the stuffing:

- Cavity-stuffed birds: one ampoule was placed in centre of the right side breast and thigh, one in the left side thigh and one in the stuffing
- Neck-stuffed birds: one ampoule was placed in centre of the right side breast and thigh, one in the left side thigh and one in the stuffing
- Unstuffed birds: one ampoule was placed in centre of the right side breast and thigh, one in the left side breast and thigh.

The temperature was monitored throughout the cooking process to ensure that the slowest heating point had reached at least 72°C. After cooking, the birds were submerged in cold water, the ampoules removed and placed in 5% hydrogen peroxide for 10 minutes. The ampoules were then rinsed in sterile distilled water, aseptically transferred into 10 ml maximum recovery diluents, crushed with a sterile glass rod and serial dilutions were prepared. Appropriate dilutions were spread plated in duplicate on nutrient agar and xylose lysine deoxycholate agar (XLD) and the plates were incubated overnight at 37°C. An additional enrichment stage was also included in which the samples were transferred to an enrichment broth to enable resuscitation of injured or low numbers of surviving cells. The enrichment involved transferring a ml volume of each undiluted sample into separate 10 ml volumes of buffered peptone water and Muller Kauffman tetrathionate novobiocin enrichment broth and incubating at 37°C overnight. In addition a ml volume was transferred to 100 ml of Rappaport Vassiliadis medium (RVS) and incubated at 42°C overnight. The enriched 10 ml BPW was subsequently transferred into RVS and Mktet and incubated for a further 24 hours. All samples were streaked onto both XLD and modified brilliant green agar plates and incubated at 37°C overnight.

Campylobacter spp. studies

Medium sized turkeys were selected to confirm the safety of the process with regard to *Campylobacter* contamination. This was in the knowledge that the *Salmonella* strains used in the microbiological challenge tests had previously been shown to be more heat resistant (therefore would survive longer during heating). Consequently, it was decided that the assessment of the microbiological safety would be best demonstrated in greater detail by the *Salmonella* data but verified by representative *Campylobacter* data.

Each turkey was inoculated using the same technique as above using glass ampoules containing a cocktail of five *Campylobacter* strains referred to previously. The three medium weight range turkeys (cavity-stuffed, neck-stuffed and unstuffed) were inoculated by inserting an ampoule in each joint of thigh with breast. This location was specifically selected for the *Campylobacter* tests in order to simulate the worst case scenario since it has been reported that the most likely area to isolate *Campylobacter* species from poultry is in the folded skin between the thigh and breast. After cooking the ampoules were removed as described above.

The turkey homogenate was recovered by crushing the ampoules in Bolton Broth, serially diluting, spread plating appropriate dilutions onto *Campylobacter* blood-free selective medium-charcoal cefoperazone deoxycholate agar (CCDA) and Preston Agar, respectively, and incubating microaerophilically for 2-5 days at 41.5°C. After incubation, the plates were examined for enumeration/presence/absence of *Campylobacter*.

The Bolton Broths were reincubated microaerophilically for 24 and 48 hours at 41.5°C and streaked onto CCDA and Preston Agar. The plates were incubated microaerophilically at 41.5°C for 2-5 days and were examined for presence/absence of *Campylobacter*.

Appendix 4

Temperature data during cooking at 180°C for neck stuffed turkeys

Measured temperature data obtained from neck stuffed turkey weight ≈3.3kg

Weight ≈3.3kg	Oven 1	Oven 2	Oven 3
Time to 72°C (minutes)	161	157	151
Stuffed weight (kg)	3.31	3.37	3.40

Measured temperature data obtained from neck stuffed turkey weight ≈5.5kg

Weight ≈5.5kg	Oven 1	Oven 2	Oven 3
Time to 72°C (minutes)	179	177	183
Stuffed weight (kg)	4.77	5.00	4.93

Measured temperature data obtained from neck stuffed turkey weight ≈7.5kg

Weight ≈7.5kg	Oven 1	Oven 2	Oven 3
Time to 72°C (minutes)	243	240	260
Stuffed weight (kg)	8.81	7.81	8.63

Appendix 5

Sensory evaluation scores for neck-stuffed turkey cooked according to the cooking instructions given (these were developed from the measured temperature data given above)

Weight (kg)	Cooking time (minutes) from linear equation	Sensory evaluation scores
Low (≈3.3)	45 per kg + 20	6
Medium (≈5.5)	40 per kg + 20	7
High (≈7.5)	30 per kg + 20	8

***safe*food**
7 Eastgate Avenue, Eastgate, Little Island, Co. Cork
7 Ascaill an Gheata Thoir, An tOiléan Beag, Co. Chorcaí
7 Aistyett Avenue, Aistyett, Wee Isle, Co. Cork

Tel: +353 (0)21 230 4100 ***Fax:*** +353 (0)21 230 4111
Email: info@safefood.eu ***Web:*** www.safefood.eu

HELPLINE
NI 0800 085 1683
ROI 1850 40 4567
www.safefood.eu