

Donairs (Gyros) - Potential Hazards and Control

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ABSTRACT

Because of concerns that meat in donairs could allow growth of pathogens during cooking and overnight cooling of leftovers, 34 donairs from eleven establishments had temperatures taken and were examined microbiologically. Temperatures varied depending on depth of measurement and stage from the raw product to reheated leftovers. These were frequently >4 or $<60^{\circ}\text{C}$ and could be considered at temperatures favorable for growth of pathogens. Although aerobic colony counts were high (mean of 10^5 to 10^7 CFU/g), counts tended to decrease the longer the donair remained cooking on the spit. *Staphylococcus aureus*, *Bacillus cereus*, *Clostridium perfringens* and *Escherichia coli* were never more than $10^4/\text{g}$ despite some abusive practices, such as leaving donairs on the spit with the heat source turned off because the demand was low. *Salmonella* was found only in raw chicken slices to be used in donairs. It is recommended that good hygienic practices be encouraged at donair establishments and temperature measurements of donairs taken to verify these. Only if meat is $<50^{\circ}\text{C}$ at 1 cm below the surface during cooking or $>5^{\circ}\text{C}$ for the raw product or cooled leftovers, should samples be considered for microbiological analysis unless abusive practices have been observed. Because temperatures may vary over a short period of time during cooking, at least five measurements are recommended for each stage of the donair life (raw product, cooking donair, cooled leftovers and reheating donairs).

quired. The product is popular in restaurant and fast-food outlets in the Maritimes, Ontario and Alberta.

Potential problems might arise from the fact that the center of the donair is cold (usually frozen) when the outside is cooking. This creates a temperature gradient from the center to the peripheral parts of the meat that may allow bacteria to grow. With ground meat as the meat source, spoilage organisms and lactobacilli might prevent pathogens from developing to levels that would produce toxins or cause infections. However, some strains of *Salmonella* require few organisms for an infectious dose. Therefore, cutting into partially cooked, warm areas could allow transfer of *Salmonella* to cooked, ready-to-eat slices. The greatest potential problem occurs, however, upon cooling the uneaten part of the donair at the end of the cooking period. A large mass of meat, such as a donair, takes a long time to cool and to warm up again the next day. Growth of pathogens, in particular *Staphylococcus aureus*, could allow heat resistant toxins to develop in the partially cooked meat. In some U.S. studies on donairs, *Clostridium perfringens* at a level of 10,000/g has been found just under the surface in a cooked, cooled and reheated product (3). The Canadian federal government recommends that temperatures of any barbecued, roasted or broiled meat should be at ≤ 4.4 or $\geq 60^{\circ}\text{C}$ (Food and Drug Regulation B. 14.072, 1). This regulation was not designed for the control of donairs but could possibly be applied to them. Provincial and state governments have similar, general regulations concerning storage of potentially hazardous foods, although the temperature ranges may differ slightly. If measured by these parameters, donairs would regularly fail to meet those criteria and, therefore, be in violation of these regulations. An examination of donairs in Prince Edward Island between 1979 and 1982 indicated that temperature and microbiological counts varied considerably and failure to meet the temperature criteria was frequent (2).

Therefore, as a result of the Prince Edward Island study, it was decided to carry out a survey to: (a) measure the health hazard of donairs by examining them microbiologically and through temperature readings; (b) suggest temperature measurements that would allow safe preparation of these foods; and (c) establish operator

A donair (sometimes known by other names, such as gyro, dona kebab, souvlaki, chawarma or shawirma) is a traditional Middle East lamb product. In Canada it is usually composed of beef and seasoned with spices and herbs such as pepper, onions and garlic. The meat is ground and molded in a frustrum (cone-like)-shaped mass. The fat and moisture content of the meat allows the particles to cohere especially when cold. Heating melts the fat and makes the product firm and homogeneous. The weight of a donair is usually between 6 and 14 kg, but can be as much as 40 kg. Normally, a frozen or refrigerated raw donair is impaled on a vertical spit and rotated in an open oven allowing heating elements (electric or gas) to cook the surface. When the meat surface has been broiled, it is cut into thin slices and placed directly into a sandwich made of Lebanese bread and may include a dressing of yogurt, sour cream or tahini sauce, or is kept in a warming tray until the food is re-

criteria for the processing and handling of donairs. Inspectors from the Ottawa-Carleton Regional Health Unit helped set up the schedule and arranged with the operators of the donair establishments for samples to be taken.

MATERIALS AND METHODS

Sampling

Between November 1982 and May 1983, eleven donair establishments were visited in the Ottawa area. These varied from restaurants to fast-food outlets where the donairs could be eaten or taken out. Each establishment was visited on at least two separate occasions. Donairs varied in weight from 3 to 15 kg.

Samples were obtained for microbiological analysis from the raw and cooked states. Samples from the cooked product were taken by the donair operator from the top, middle and bottom of the donair by cutting into the meat and removing several slices as if obtaining them for a customer. Similar amounts were taken from the top, middle and bottom of uncooked donairs. On occasion, representative samples were taken from raw product before forming into donairs, e.g., spiced hamburger and marinated beef slices. A knife was used to shave pieces of meat from frozen donairs. For each sample at least 100 g was collected, placed in a Whirlpak bag, and stored in a cooler for transportation to the laboratory. Duplicate samples from each location, wherever possible, were taken. All samples taken up to 4:00 p.m. were analyzed within 2 h, but samples taken after that time were refrigerated overnight and analyzed the next morning.

The knife and tongs were supplied by the franchise owner/operator. They were washed and rinsed in the two-compartment sink before use. As a means of sanitizing, the utensils were dipped in a solution of 70% alcohol and then flamed. Precaution was taken to wash, rinse and sanitize the knife and tongs after each individual sample.

Temperature measurements

Cooking temperature measurements were made at 30-s intervals with a Wahl Heat-Prober Digital Thermometer, Platinum 392. These were taken at the surface, at depths of 0.5 cm and 1 cm below the surface and at the center (spit readings) when possible, as the donair rotated on the spindle of the radiant heat cooker. Spit readings were taken as close to the metal spindle as possible, but often the meat was frozen there and spit readings then marked the boundary between thawed and frozen meat. The depth of penetration towards the center was determined at the same time. A complete rotation took about 1 min. Two types of probes were used, i.e., (a) surface probe and (b) penetration probe. Each of the probes was placed on or in the meat at the farthest point able to be reached on the right-hand side of the machine next to the heating point. With the probe securely held either on or in the meat, a digital reading was recorded when the probe approached the front of the machine (about 30 s later). Temperature measurements were determined at the top, middle and bottom of the donair, and done in duplicate on opposite sides of the donairs.

Microbiological analyses

Meat samples (11-g amounts) were analyzed for aerobic colony counts (ACC; plate count agar), *Escherichia coli* (indole-positive colonies on tryptone-bile agar incubated at 44.5°C), *S. aureus* (Baird-Parker medium and coagulase tests) and *Bacillus cereus* [Bacillus cereus selective medium (Oxoid Ltd., Basingstoke, Hants, England) and PEMPA medium (11)]. For

Salmonella determinations, 25-g amounts were preenriched in nutrient broth, enriched in selenite-cystine broth at 35°C and tetrathionate at 43°C, and plated on bismuth sulfite and brilliant green sulfa agars. All incubation temperatures were at 35°C unless otherwise stated. The analyses were done according to Health Protection Branch methodology (details available on request). In addition, pH measurements of the samples were taken with a Radiometer PHM 64.

Statistical analyses

A nonparametric (Kruskal-Wallis) test (6) was used to analyze differences among various groupings of the data. If the Kruskal-Wallis test suggested that the difference among the groupings was statistically significant ($\alpha=0.05$), then another nonparametric test (a distribution-free multiple comparison test (6) based on the Kruskal-Wallis test) was used to examine the pair-wise differences among the groupings under consideration. Mean counts, unless otherwise noted, are arithmetic means where a value of zero was given for each nondetectable count. Where \log_{10} values were used, the value of 1 was added to each count before log calculations were made. The addition of 1 is a standard statistical technique used when zero values are present in the data, and has a negligible effect on the results (9).

RESULTS

Bacteriological counts

From the eleven establishments, 34 donairs were examined and 587 samples of raw, cooked, stored and reheated meat taken. In addition, 530 temperature readings were recorded. Mean ACCs of uncooked donairs (10^7 CFU/g) resemble those found in hamburger meat (3,5,8,10) and counts of pathogens *S. aureus*, *B. cereus* and *C. perfringens* (present in $\leq 20\%$ of samples) were less than 10^4 /g. *Salmonella* was found only in 0.9% of the samples (raw chicken slices). The presence of *Salmonella* in chicken is not surprising. However, if donair cooking temperatures are not high enough, *Salmonella* could grow in the product.

The number of samples taken from donairs in each establishment varied from 17 to 91 (mean, 51) for ACC, with mean levels ranging from 10^5 to 10^7 CFU/g which indicates limited variation. Similarly, counts of organisms indicative of a potential health hazard varied from establishment to establishment but differences were slight (nondetectable to 10^2 /g mean values) and higher counts for one organism did not mean that they would necessarily be high for other organisms. Duplicate samples were taken from each donair and most raw ingredient samples where sufficient mass permitted; on donairs that were almost finished, the meat slices had to be taken from all parts of the remaining portion to obtain the 100 g required and no duplicates were possible. For all stages of the preparation, cooking and storage, most counts ($>85\%$) of duplicates varied by 1 \log_{10} or less per g.

The raw meat sold to the establishments came from six meat suppliers. Five of these were meat markets, the sixth supplier was a manufacturer of uncooked frozen prepared donairs from Moncton, New Brunswick.

Supplier No. 1 (an Ottawa meat market) had the lowest counts for ACC and *E. coli*. By the time the meat was cooked, however, counts of donairs made from meat obtained from supplier No. 1 were not statistically different from counts of donairs made from other sources of meat. The majority of the donairs were made with ground beef. However, two establishments used beef slices, one chicken slices, one ground beef interspersed with slices of lamb, and one used two-thirds ground beef and lamb, one-third chicken slices interspersed in the ground meat. Counts of donairs made with ground beef (10^7 ACC/g, mean values) tended to be higher than those made with other products (10^4 to 10^5 ACC/g, mean values).

For the cooked product, the differences between samples taken from establishments using gas ovens and those using electric ones were not significant. Similarly, any differences in microbiological counts taken at the top, center and bottom of each donair were not significant. When counts were examined at various stages in donair preparation, cooking and storage, it was observed that the highest counts (10^7 ACC/g, 10^3 *E. coli*/g) occurred in the raw meat (Figure 1). Marination or addition of spices lowered the counts only slightly. As to be expected, cooking for 1 h or less marginally lowered ACCs and *E. coli* levels. Only when donairs were cooked for over 1 h were ACCs less than 10^5 CFU/g and *E. coli* counts not detectable. Storage overnight of unfinished cooked donairs in refrigerators or freezers did not markedly change these counts, and only when these donairs were reheated the next day for over 1 h did ACCs reach over 10^7 CFU/g again, although *E. coli* was no longer found.

pH

The mean values of pH for raw ingredients and uncooked donairs (pH 5.8), cooking donairs (pH 5.9), in cold storage overnight (pH 6.4) and reheated donairs (pH 6.1) indicate a slight rise in pH during cooking and storage. The lower pH values of the raw ingredients can be explained by the fact that some of these were marinated (pH 4.5 to 5.1, mean pH 4.8).

Temperature

Mean temperatures of raw ingredients and uncooked donairs and also refrigerated or frozen stored cooked donairs were $<10^\circ\text{C}$, although some individual readings were considerably higher (Table 1). Once on the spit, the mean temperatures of the cooking donairs at the surface, 0.5 cm and 1 cm below the surface changed little (50 to 56°C), although the ranges and standard deviations indicated that there was considerable fluctuation between individual readings. Reheated donairs had mean temperatures ranging from 54 to 60°C (1 cm below the surface to the surface). As might be expected, spit temperatures did not respond quickly to heating or cooling changes. The spit temperatures of the cooking product were, in general, substantially lower than the other temperatures measured. However, for those donairs heated for a long time, the spit temperatures eventually approached those at or near the surface. This was because (a) heat more easily penetrated to spit depths as the mass of the donair was reduced, and (b) the metal spindle on which the donair rotated itself became hot and radiated heat into the cool interior. Figure 2 clearly illustrates the relationship that exists between spit and other temperatures. Lines joining symbols indicating temperature readings at

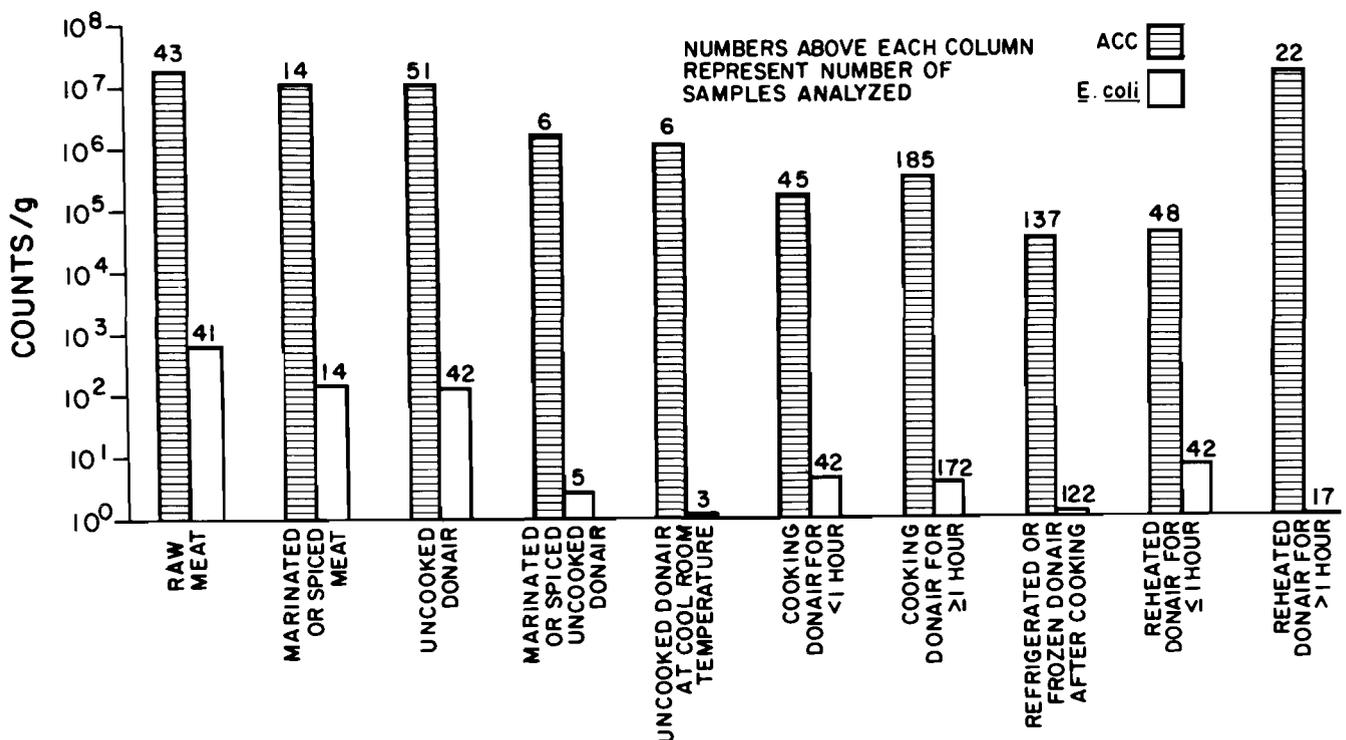


Figure 1. Mean ACCs and *E. coli* counts in relation to raw ingredients, cooked product, cooled leftovers and reheated donairs.

different depths are for the convenience of the reader and do not imply trends between readings. This also applies to Figures 3 and 4. On Day 1 from refrigerated conditions, the donair heats rapidly near the surface within 30 min and temperatures tend not to go much higher than 60°C for the remainder of the cooking period. This is because the operator does not want the meat to be overcooked and he turns the heat source down or off. This also explains the uneven temperature gradients. The one

noticeable dip to 22°C (surface) at 210 min occurred because the operator had turned the heat off for several hours after the noon-time rush was over. It is noticeable from this that the surface cools faster than the center. The reheating process on Day 2 was similar to the cooking process on Day 1.

Where duplicate readings (i.e., two from opposite sides of the donairs) were taken from the top, center and bottom, variations between these duplicates did occur and

TABLE 1. Summary of donair temperatures for four stages at specific locations.

Stage	Depth of temperature measurement	No. of readings	Temperatures (°C)		
			Mean	Range	Std. Dev.
Raw ingredients and uncooked donairs	Surface	119	3.0	-11-13	6.6
	0.5 cm below surface	58	7.2	-5-22	6.2
	1 cm below surface	51	6.5	-5-16	4.4
	Spit	27	2.5	-6-15	6.2
Cooking donairs	Surface	310	55.7	16-102	17.1
	0.5 cm below surface	310	50.7	16-95	15.9
	1 cm below surface	311	53.8	16-82	15.1
	Spit	301	34.3	-5-79	22.3
Donairs stored after cooking	Surface	39	3.8	-4-15	5.5
	0.5 cm below surface	36	9.4	-4-19	4.8
	1 cm below surface	39	4.3	-4-15	5.8
	Spit	34	1.2	-7-17	8.4
Reheated donairs	Surface	68	60.2	34-85	15.0
	0.5 cm below surface	70	54.7	30-88	15.1
	1 cm below surface	70	53.6	26-78	14.2
	Spit	70	31.4	-4-83	24.3

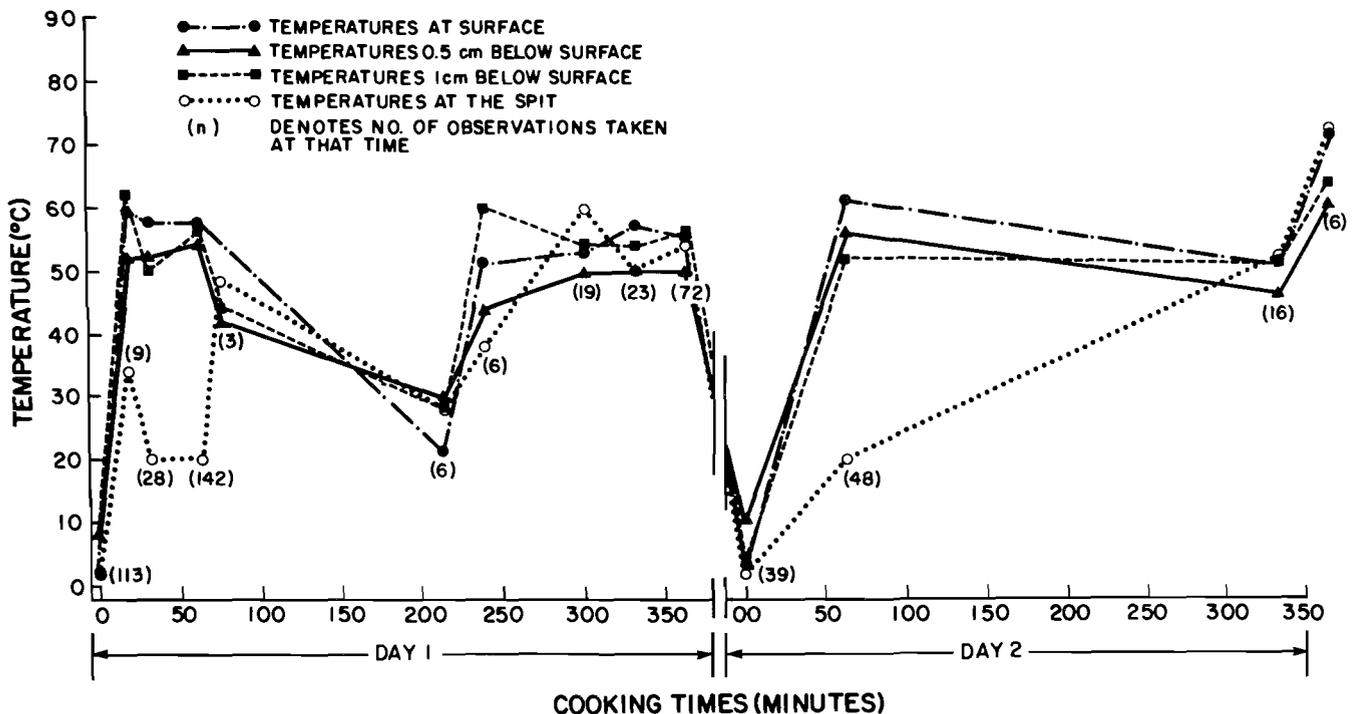


Figure 2. Relationships between temperature readings at the surface, 0.5 and 1 cm below the surface and at the spit in donairs during preparation, cooking, storing leftovers and reheating donairs.

surface readings had a wider spread than those from other locations (Table 2). In fact, the duplicate spit readings had the least differences. A few of the variations in temperature at the surface and 0.5 cm below the surface were extreme. For instance, one donair had all six pairs of duplicate cooking temperatures with differences between the duplicates ranging from 28 to 45°C. Uneven heating of the donair probably caused these differences. In a few establishments, automatic rotating spits were not available or were not used and turning was done by hand at times felt to be appropriate by the operator. If temperature measurements are used to assess quality of a donair, this uneven heating, if it occurs, must be taken into consideration. Despite these types of variation, temperatures at the surface, 0.5 cm and 1 cm below the surface were highly correlated (Table 3), indicating that a reading taken at one level is representative of temperature taken at the other levels. Spit temperatures, however, tended to be more independent of the others, because they were furthest from the heat source.

Comparison of bacterial counts and temperature readings

Bacteriological counts did not correlate well with temperature results at any of the depths in the donairs (Table 3). This is not unexpected, because a fluctuation in temperature will not necessarily cause any bacteriological change in numbers for several hours. Nevertheless, the two types of results can be discussed. The following are profiles of four types of donairs encountered on the survey.

1. The first example is a typical donair made of spiced ground beef prepared in a fast-food establishment and lasting 2 d. Although recorded temperatures in the meat failed to reach 60°C (range -2 to 53°C on Day 1), during the cooking counts fell (e.g., from 10⁷ ACC/g raw product to 10⁵ ACC/g cooked donair). Counts did not increase substantially during the overnight cooling phase and dropped a further log₁₀ during the next day's broiling. Figure 3 shows that as temperatures go up, counts come down and vice versa. *S. aureus*, *B. cereus* and *E. coli* were present in low numbers only in the uncooked product, but *C. perfringens* survived the cooking and freezing to be a potential problem if donair slices had been left at room temperature for a lengthy period of time. The pH of the product ranged from pH 6.1 (raw donair) to 6.4 (cooking donair).
2. Restaurants tend to prepare donairs for meal times, i.e., at noon and in the evening, and may prepare only one or two donairs a week. In one example, a small (3 kg) donair was made from fresh ground beef, spices and sliced lamb at 10 a.m. and put on the spit at 11 a.m. to be ready for diners at 11:30. The whole donair was finished by 2 p.m. Although ACCs were high in the ground beef (10⁸ CFU/g), the rapid cooking reduced levels to 10⁴ CFU/g. *S. aureus* and *E. coli* were eliminated in the broiling process.
3. Occasional abuses were noted in the preparation of

TABLE 2. Differences between duplicate measurements of temperature readings.

Location of temperature readings	No. of duplicate measurements done	Differences between duplicate results									
		≤5°C	6-10°C	11-15°C	16-20°C	21-25°C	26-30°C	31-35°C	36-40°C	41-45°C	>45°C
Surface	249	174 (69.9%)	24 (9.6%)	24 (9.6%)	7 (2.8%)	5 (2.0%)	6 (2.4%)	3 (1.2%)	1 (0.4%)	4 (1.6%)	1 (0.4%)
0.5 cm below the surface	232	171 (73.7%)	32 (13.8%)	10 (4.3%)	4 (1.7%)	3 (1.3%)	3 (1.3%)	3 (1.3%)	2 (0.9%)	2 (0.9%)	2 (0.9%)
1 cm below the surface	228	178 (78.1%)	30 (13.2%)	12 (5.3%)	2 (0.8%)	4 (1.8%)	2 (0.8%)	-	-	-	-
Center of the donair (Spit reading)	207	181 (87.4%)	18 (8.7%)	4 (1.9%)	3 (1.4%)	-	-	-	-	-	1 (0.5%)

TABLE 3. Correlation coefficients for donair temperatures at specific locations and ACCs.

Parameters compared	No. of readings used	Correlation coefficient
0.5 cm temp. vs. 1.0 cm temp.	462	0.92
Surface temp. vs. 1.0 cm temp.	452	0.92
Surface temp. vs. 0.5 cm temp.	454	0.90
1.0 cm temp. vs. Spit temp.	430	0.61
Surface temp. vs. Spit temp.	414	0.50
0.5 cm temp. vs. Spit temp.	430	0.48
\log_{10} ACC vs. Surface temp.	516	-0.50
\log_{10} ACC vs. 1 cm temp.	448	-0.44
\log_{10} ACC vs. 0.5 cm temp.	451	-0.42
\log_{10} ACC vs. Spit temp.	415	-0.31

donairs. In one fast-food facility, a frozen prepared donair was left at a cool room temperature for 8 to 10 h waiting for a demand that did not materialize. It was refrozen in the evening and cooked the next day. However, because of few customers the operator turned the broiler off for long periods of time and at the end of the second day refroze the remainder (10^5 ACC/g). At the end of the third day there was little left (no top portion was available for testing); counts were undesirably high (10^8 ACC/g), with *B. cereus* and *C. perfringens* present. In general, as would be expected, counts increased when the product was left at room temperature but decreased during cooking (Fig. 4).

4. The last example is similar to the third one, i.e., a product kept for 3 d because of slow customer demand, except that marinated spiced meat was used. Although the pH was not unduly low (pH 5.2 to 6.0), counts were not as high as in the previous example (10^6 ACC/g after being frozen overnight reducing to 10^3 ACC/g after being reheated and left at room temperature). The donair was exposed to high temperatures during the cooking which may have prevented excessive growth. In addition, the marinating of the sliced meat may have been a factor in inhibiting rapid growth.

DISCUSSION

Proposed 3-class acceptance plans

There are several ways of determining whether or not a donair is a potential hazard: (a) to observe the preparation and the sanitary handling of the products, (b) to perform microbiological counts on portions of the meat, (c) to take temperature measurements, or (d) a combination of all three approaches.

The first approach is probably the one most often done, but will only detect gross mishandling practices. The second is valid but time-consuming and should only be done if an illness has occurred or there is good reason to suspect excessive microbial growth. The third ap-

proach gives immediate answers as to whether or not a donair should be allowed to remain on sale but, as previously indicated, does not correlate well with microbiological counts. If temperatures are to be used as a measure of hazard, this has to be done with care because of the fluctuation between readings. The use of 3-class acceptance plans allows for a certain amount of variation (7).

Two 3-class plans are suggested to give a reliable measure of the health risk of the product. The first is for the uncooked raw ingredients or donairs and also for those that have been stored overnight in the cold: m (maximum temperature that is of no concern) = 5°C , M (temperature which indicates potential spoilage or a health hazard) = 12°C , c (maximum number of measurements which may have a temperature higher than m but less than M , without the meat failing to meet the guidelines) = 2, n (number of temperature measurements, representative of all parts of the meat, to be made) = 5. The second plan is for cooking or reheating donairs: m (minimum temperature that is of no concern) = 50°C , M = 40°C , c = 2, n = 5. All temperature readings are to be 1 cm in from the surface; the 1 cm depth was chosen because (a) this is deeper than the operator would cut to serve a customer, and (b) if the operator turned on the heat on suspecting an inspection, the heat would take a few minutes to penetrate the 1-cm level. These 3-class plan limits are more lenient than typical temperatures for storage of potentially hazardous food (≤ 4 or $\geq 60^{\circ}\text{C}$). Yet, when these in turn are applied to the 34 donairs examined, 50% of them did not meet these guidelines. Five of these failed at more than one stage (uncooked meat, cooking, storage overnight and reheating). ACCs were excessive in only four of the 17 donairs rejected ($\geq 10^8$ CFU/g, a raw product; $\geq 10^6$ CFU/g cooking or reheated product). Therefore, temperature measurements should not be used to prevent sale of a donair outright, but rather as a screening technique. Those that fail to meet the guidelines should have a microbiological analysis done and a warning should be issued only after high ACCs or presence of $\geq 10^3$ of *S. aureus*, *B. cereus*, *C. perfringens* or *E. coli* per gram are found. Apart from temperature abuse, other improper hygienic practices may also indicate sampling for microbial counts should be done.

Guidelines for preparing donairs

These are suggested for operations to prepare a safe and wholesome product. They are similar to those published by Bryan et al. (3).

1. Obtain meat from a source approved by health and agriculture authorities.
2. Prepare the donair from freshly ground meat.
3. Make the donairs as small as is practical, i.e., a size that can be cooked and served in one day.
4. Freeze the donairs as soon as they are prepared and keep them frozen until they are delivered to the operators.

5. Cook the frozen product continuously except during slicing, and make sure that the surfaces are evenly heated by keeping the spit rotating constantly according to manufacturers' instructions. Do not turn off the heat source and leave the donair at room temperature.
6. Thoroughly cook the outside of the donair before cutting off slices. The temperature of the meat 1 cm in from the surface should be $\geq 50^{\circ}\text{C}$ (122°F) within 60 min of the beginning of cooking. Make sure the

- temperature-reading device you use is operating correctly according to the manufacturer's instructions.
7. Serve slices as soon as they are cut. If this is not possible, store the slices at $\geq 60^{\circ}\text{C}$ (140°F), preferably in an enclosed hot-holding facility. Do not sell any unused stored slices after the end of the day.
8. To keep donairs for sale after the end of the day, cool them rapidly. The meat throughout the donairs must be $\leq 5^{\circ}\text{C}$ (41°F) within 2 h of removal from the heat source. Practically, this can be achieved by

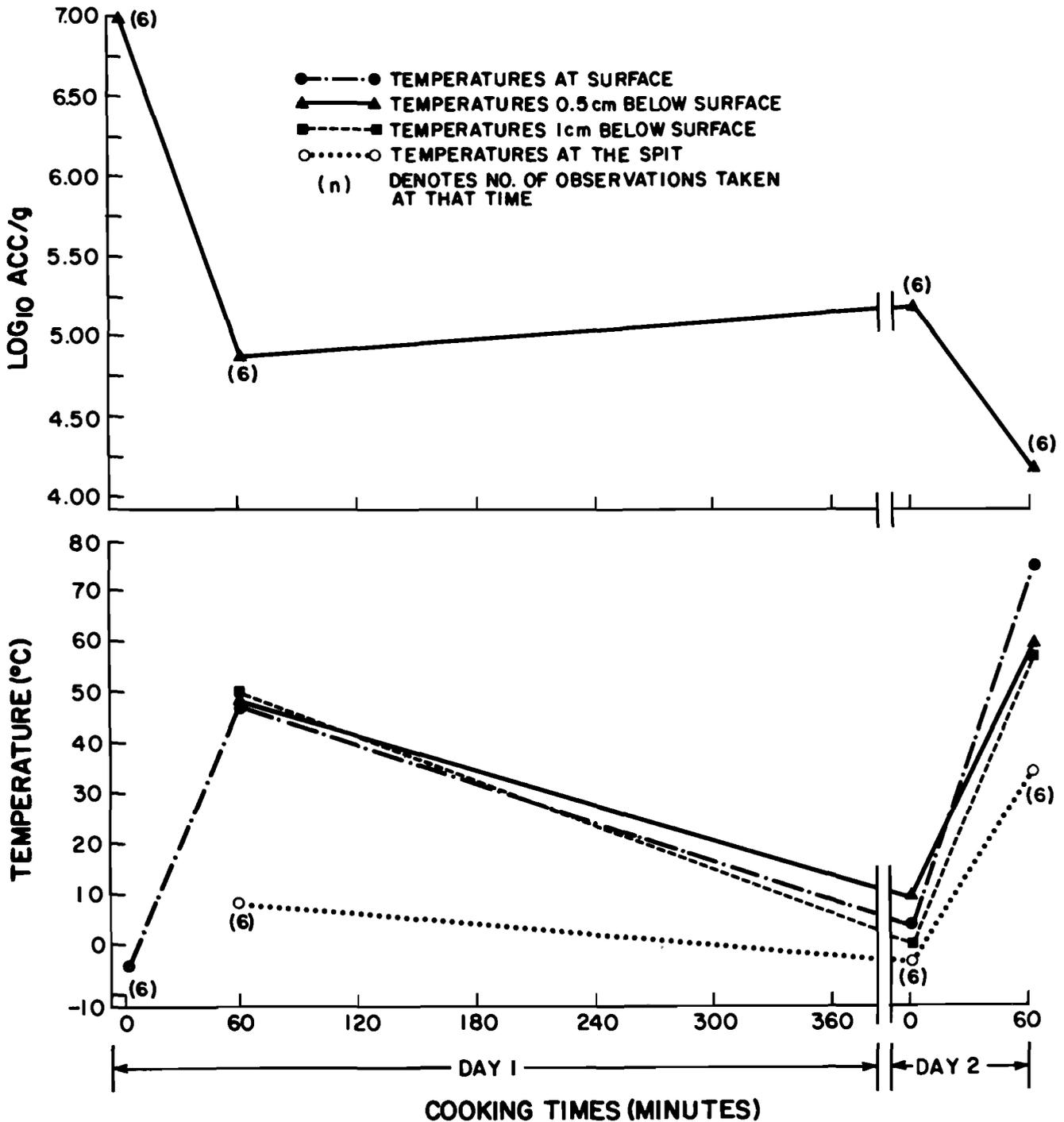


Figure 3. ACCs and temperature changes during the preparation, cooking and storing of leftovers and reheating of a typical donair in a fast-food establishment.

blast air cooling or cutting donairs into smaller portions (recommended size: ≤ 10 cm in diameter) and cooling them in a freezer.

9. Reheat frozen donair leftovers as soon as possible; the meat 1 cm below the surface should be $\geq 50^{\circ}\text{C}$ (122°F) within 60 min of beginning the heat process. Heating processes other than spit-roasting, e.g., microwave ovens or pressure cookers, may have to be used. Do not mix raw product with left-over products.
10. Slice reheated donairs and, if necessary, store the slices as for freshly frozen donairs.
11. Make sure that unsold reheated products are not frozen and reheated again for sale at a future time.

12. Clean and disinfect the cooking apparatus at least once a day. Other equipment, such as knives, pans, etc., should be cleaned and disinfected regularly throughout the day according to good hygienic practices.

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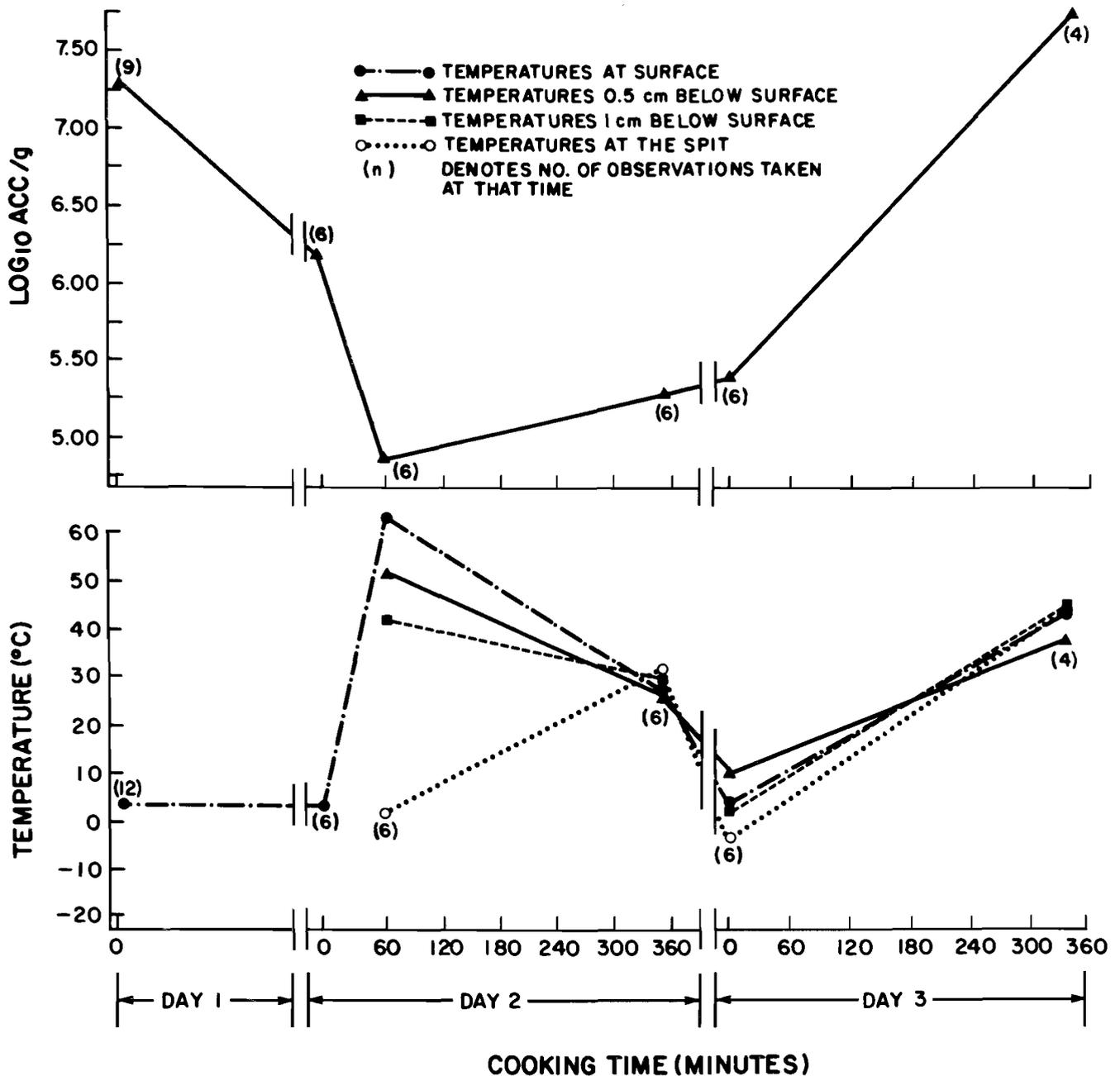


Figure 4. ACCs and temperature changes during the preparation, cooking and storing of leftovers and reheating of a donair that was left at room temperature for long periods of time in a fast-food establishment.

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