Microbial Hazards of Street-Vended Grilled Chicken Intestine

Ma. Patricia V. Azanza* and Arlyn I. Gedaria
Department of Food Science and Nutrition
College of Home Economics, University of the Philippines
Diliman, Quezon City, Philippines 1101
E-mail: mpazanza@che.upd.edu.ph

ABSTRACT

Microbial hazards associated with street-vended grilled chicken intestine (*isaw*) were studied. Grilling of *isaw* effected ≥89.00% decrease in the total microbial load of the sample. Cooked *isaw* contained about 10^5-10^6 cfu/g aerobic plate counts and 10^3-10^4 MPN/g coliform counts. *Salmonella* per 25 g sample was isolated from cooked *isaw* samples. Grilling eliminated *Staphylococcus aureus* and *Listeria monocytogenes* cells initially present in pre-cooked samples. Different sauces of *isaw* showed increasing numbers of total aerobic microorganisms and coliform during vending operations. The total plate counts and coliform counts of the sour sauce, which ranged from 10^3-10^5 cfu/g and 10^1 MPN/g, respectively, were observed to be lower than those found in the sweet sauce. Sources of microbial contaminants of grilled chicken *isaw* included the natural flora of the raw materials, contaminations from food-contact surfaces, bamboo skewers, and the hands of the food handlers. Among the critical control points identified in the street-vending operation of chicken *isaw* were the control of time and temperature during cooking and hold-on periods during vending operations.

Key words: microbial hazards, streetfood, HACCP

INTRODUCTION

The selling and consumption of street-vended grilled chicken *isaw* has become a part of street culture in the Philippines. Variants of *isaw* include other grilled chicken parts like the head, feet, and gizzard. These chicken products are eaten with different sauces prepared by the vendors themselves. Chicken offals as street foods were only recently developed as snack items in the Philippines. This development may be attributed to the worsening poverty in the last two decades and the consequent search for cheap alternative food items.

The microbial risks associated with the consumption of grilled chicken intestine are quite high. Poultry and poultry products are extremely perishable and usually harbor pathogenic microorganisms. Chicken products have been reported as vectors of food poisoning outbreaks (Longree and Armbuster, 1996). These types of products are listed as major reservoirs of *Salmonella*. Handy et al. (1964) reported that normal tissues of poultry, skin, and gut were also major sources of *staphylococci*.

The application of Hazard Analysis Critical Control Points (HACCP) system to street food is recommended by food safety experts (Abdussalam,1987; Bryan, 1992). This food safety system has been applied to local street-vended food products sold in schools in San Juan, Rizal and Los Baños, Laguna, Philippines (de Guzman, 1994).

**Corresponding author*

This study was conducted in order to establish microbial hazards associated with street-vended chicken *isaw* sold within the University of the Philippines (UP) Diliman. The results of the study were used to educate *isaw* vendors and health officials on the test campus regarding control in the vending operations of grilled chicken intestine.

MATERIALS AND METHODS

Street vendors

The preparation, storage, and vending procedures for chicken *isaw* of three selected vendors operating on the campus of UP Diliman were observed. These street vendors peddled *isaw* in push carts which they stationed in strategic places during their street-vending operations. Vendors selected for the study were those who have been selling *isaw* for at least six months. These vendors willingly cooperated in the interviews and allowed observations of their street-vending operations and sampling of the test street food. Results of interviews and observations were used to develop a food flow for the street-vending operations of *isaw*.

Quality assessment

Microbiological and physico-chemical characteristics of pre-cooked and cooked chicken *isaw* and its different sauces were assessed. Cooked chicken *isaw* were sampled immediately after grilling. Pre-cooked chicken *isaw* on hold-on display were sampled at 0, 3, and 6 h. Pre-cooked and grilled chicken *isaw* from 10 skewers were sampled and analyzed per trial. Sauces sampled at 0, 3, and 6 h during vending operations were taken directly from sauce bottles. Test *isaw* and sauce samples were taken aseptically and placed in sterile plastic containers for testing at the food laboratory. Three separate trials were done for each of the different vending schedules on separate days of sampling for every participating vendor. Analyses were done in duplicates per trial.

Microbiological analyses of bamboo skewers and the surface of the hands of the vendors were likewise done. Results of quality assessment were used in determining the microbial hazards and critical control points in the developed food flow.

Physico-chemical tests

Physico-chemical properties including pH, Aw, and temperature of the test street food and its different sauces were determined. Street food samples were homogenized in a blender and prepared in duplicates for analysis. For the measurement of pH, the homogenized samples were prepared and two pH readings per replicate were taken.

The pH of the sample was measured using a Chemcadet Model pH meter (Cole Parmer, USA). The Aw of the test sample was analyzed using the Wert-Messer Aw value analyzer (Model 583, Germany). $ABaCl_2$ solution was used to calibrate the Aw meter. The temperature of the test sample was recorded using a digital Fluke 52 K/J Thermometer (John Fluke Co., USA) equipped with piercing probe, immersion probe, and air probe to monitor the internal temperature of the pre-cooked and cooked chicken *isaw*, sauces, cooking oil, and the burning charcoal.

Microbiological tests

Indicator microorganisms

Total Plate Count (TPC) and coliform count were used to assess the total microbial and fecal contamination of the test street food, respectively. The total microbial load of *isaw* and its sauces was analyzed by homogenizing 10 g of the *isaw* and 10 ml of each of the sauce samples with 90 ml 0.1% peptone water. Further serial dilutions were conducted using 0.1% peptone water. One ml of each of the last three dilutions was pour plated using plate count agar and incubated at 35°C. Colonies were counted and reported as cfu/g or ml sample.

The presence of coliform was analyzed using Most Probable Number (MPN) (Australian Standard 1987). The food samples were diluted using peptone water. One ml of each of the last three dilutions were inoculated into Lauryl Tryptose (LT) broth. Inoculated tubes were

incubated for 24 h at 35°C. Loopfuls of samples from LT tubes with positive reactions (turbidity and gas formation) were streaked onto solid Eosin Methylene Blue Agar (EMB) and was incubated at 35°C. The colonies with green metallic sheen on EMB Agar confirmed the presence of coliforms. The results of the tests were reported as MPN/g or ml sample.

Pathogenic Microorganisms

The presence of pathogenic microorganisms including *Staphylococcus aureus*, *Salmonella,* and *Listeria monocytogenes* per 25 g samples was analyzed. Presumptive tests for the detection of *Salmonella* was based on the Standards Reference Methods of Australia, AS 1766.2.5-1989 (SAA, 1989). Twenty five g streetfood samples were placed in buffered peptone for microbial resuscitation and incubated for 16-20 h at 37°C. Resuscitated cultures were transferred to Mannitol Selenite Cysteine Broth (MSCB) for 16-20 h at 37°C Loopfuls of sample from positive tubes, as indicated by the appearance of brick red color of the broth, were streaked onto Bismuth Sulfite Agar (BSA) and incubated at 37°C for 24-48 h. Black colonies on BSA were subjected to biochemical tests to confirm the presence of *Salmonella.* The biochemical tests used to detect the presence of *Salmonella* showed negative reaction to KCN tolerance, urease production, and indole formation tests, and positive reaction to lysine decarboxylase production (Bacteriological Analytical Manual, 1992; Bergey's Manual of Determinative Bacteriology, 1994).

The presence of *S. aureus* in pre-cooked and cooked chicken *isaw* and its sauces was detected using Australian Standard Reference, AS 1766.24 (SAA, 1986). The test street food was homogenized and enriched in 0.1% peptone water. Loopfuls of the samples were inoculated into trypticase soy broth with 10% NaCl and 1% sodium pyruvate and incubated at 35°C for 48 hours. Loopfuls of broth culture were streaked into Baird Parker Agar (BPA) and incubated at 35°C for 48 hours. Black colonies surrounded by clear zones were inoculated into Brain Heart Infusion (BHI) broth and were subjected to coagulase test by adding coagulase plasma with EDTA. The formation of clot in BHI broth confirmed the presence of *S. aureus.*

The Australian Standard 1095, Microbiological Method for the Dairy Industry (Anonymous, 1987) was used to detect *L. monocytogenes*. Twenty five grams of pre-cooked and cooked chicken intestine samples and the sauces were resuscitated in *Listeria* pre-enrichment broth and were incubated at 30°C for 24 h. One ml of resuscitated culture was inoculated into *Listeria* selective solid media and incubated at 30°C for 48 h. Grey colonies observed under obliquely transmitted light from the *Listeria* selective solid media were inoculated into trypticase soya agar with 0.6% yeast extract. Biochemical tests indicating the presence *L. monocytogenes* per 25 g sample showed negative reduction of nitrate and negative reaction to urea hydrolysis test. Also, *L. monocytogenes* colonies were able to ferment and form gas from dextrose, maltose, and rhamnose, but not from mannitol and xylose (Lovett, 1988).

RESULTS AND DISCUSSION

Street-vending operations

Fig. 1 shows the representative food flow diagram for the street-vending operations of chicken *isaw*. The food flow was developed based on the information given and the observation of the three participating chicken *isaw* vendors. Major phases of the vending operations for chicken *isaw* include pre-cooking, skewering, grilling and dipping into sauces. All these, except pre-cooking, were done in the food carts. Pre-cooking of the intestines was normally completed in the respective households of the vendors.

Pre-cooked chicken *isaw* samples were displayed under ambient conditions during the 6 h vending operations. The grilling area was located beside the food cart. Different sauces of chicken *isaw* were contained in open jars at ambient conditions during vending operations.

Raw chicken intestines were delivered to the residence of Vendor A every morning. Upon delivery, the intestines were washed with potable running water. Washed chicken intestines were pre-cooked, boiling them in light brine with vinegar for about 2 to 3 min before being skewered with bamboo sticks. Diluted food grade orange coloring was brushed onto the surface of

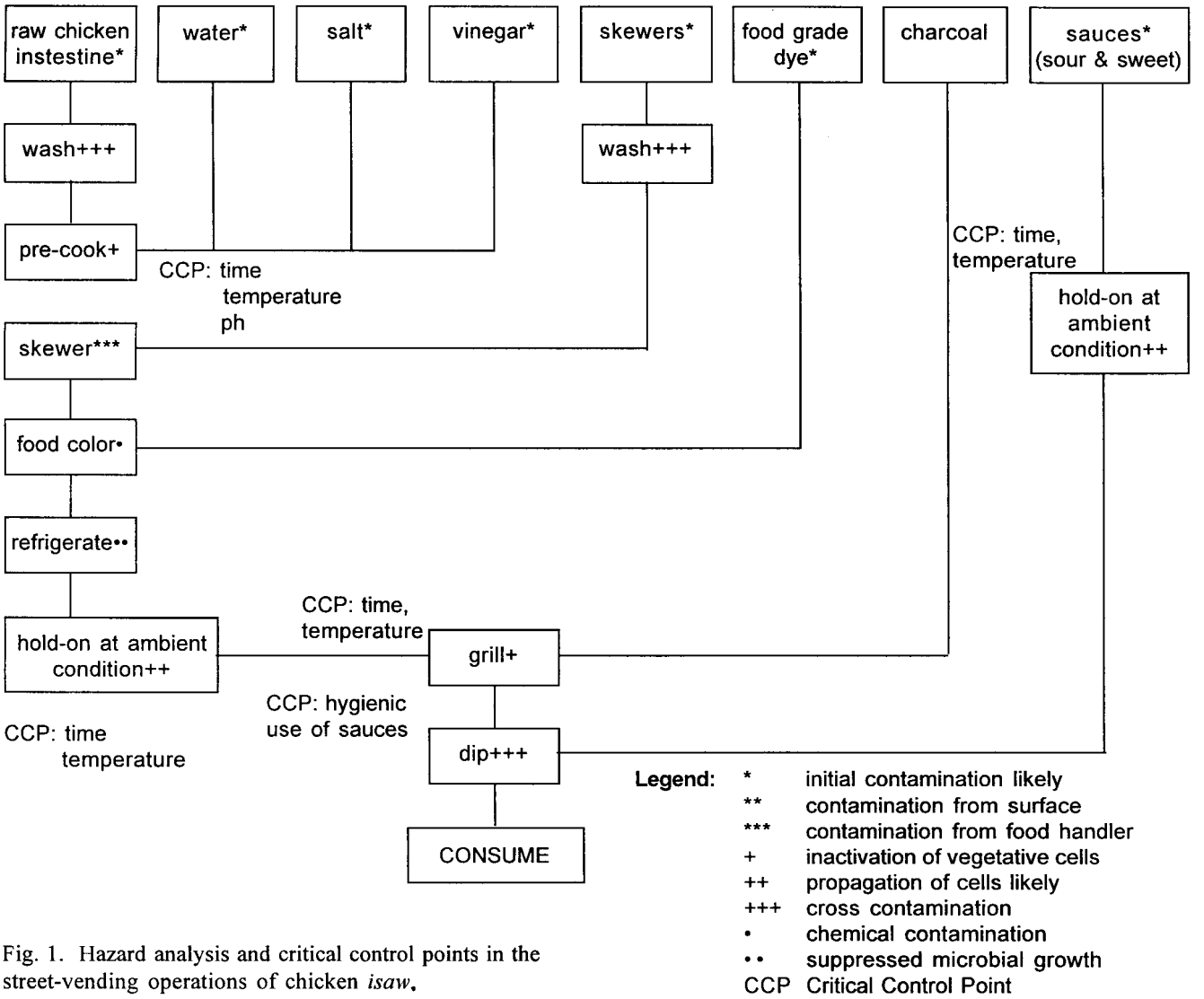

Fig. 1. Hazard analysis and critical control points in the street-vending operations of chicken *isaw*.

skewered chicken *isaw* to enhance its color. Pre-cooked chicken *isaw* samples were then stored in the refrigerator for about 1 to 3 hours.

Vendor A prepared around 200 to 300 skewered chicken *isaw* from 30 k of chicken intestines purchased daily. Vending operations normally started at 4:00 pm until 10:00 pm outside a local church on UP Diliman campus. All other barbecued products to be grilled, such as chicken feet and head, were stocked and displayed in an uncovered tray on the food cart and were held under ambient conditions during vending operations. A small iron grill was normally placed beside the cart. Skewered chicken *isaw* samples were cooked on top of an improvised iron grill with burning charcoal underneath. The degree of cooking of chicken *isaw* depended on customer preference. The iron grill was hardly cleaned by the vendor during vending operations.

The sweet and the sour sauces of chicken *isaw*, were prepared by Vendor A. No fixed sauce formulations were used for the different sauce preparations. Sauces were placed in uncovered jars during vending operations. Customers prefer to dip their cooked chicken *isaw* from one sauce to another. Vendor A stored left-over chicken *isaw* in the refrigerator and disposed of whatever was left of the sauces.

Vendor B received his supplies of chicken intestines from a chicken dealer who made deliveries every morning. Vending operations started at 4:00 pm and ended at 9:00 pm. The practices of Vendor B were similar to the chicken *isaw* vending operations of Vendor A.

Vendor C purchased her supply of chicken intestines from a chicken dealer operating near the campus. She sold other barbecued products, such as chicken feet, chicken head, and pork barbecue. Vending operations of Vendor C started at 4:00 pm and ended at 9:00 pm. The vending practices of Vendor C were similar to those of Vendors A and B.

Physico-chemical characteristics

Table 1 shows the physico-chemical properties of pre-cooked chicken *isaw* on hold-on display under ambient conditions during vending operations. The pH readings of pre-cooked chicken *isaw* decreased during the vending operations. The pH readings of the pre-cooked chicken *isaw* were between 5.37 to 6.10 and 4.70 to 4.90 at the start of vending operations and after 6 h on hold-on display, respectively. These pH values are below the approximate pH values for fresh chicken products of about 6.20-6.40 (Mossel et al., 1995). Cooking of the product in light vinegar may be the reason for the decrease in the pH values of pre-cooked samples. The decrease in the pH values of pre-cooked *isaw* stored under ambient conditions may be due to the effects of several types of deterioration. Spoilage in meat has been attributed to the activities of enzymes on the fatty acids or other organic acids like lactic acid, the end result of either chemical or microbial deteriorations (Frazier and Westhoff, 1988).

The Aw of pre-cooked chicken *isaw* shows a decreasing trend during the six-hour vending operations. The Aw values ranged from 0.910-0.940 and 0.817-0.920 at the start of the vending operations and after six hours of hold-on display, respectively. This reduction in Aw may be attributed to dehydration of the product while on display. Skewered pre-cooked chicken *isaw* were stacked on trays and exposed to the environment during hold-on display. Also, the trays were placed near the grilling areas. The dehydration of the samples was inevitable as a result of exposure to wind and heat over the six-hour period.

Table 1. Physico-chemical properties of pre-cooked chicken *isaw* on hold-on display during street-vending operations*

Vendor	Vending time (h)	Physico-chemical tests		
		pH	Aw	Temp (°C)
A	0	6.10	0.935	25.95
	3	5.00	0.919	26.10
	6	4.70	0.817	25.33
B	0	5.87	0.910	26.67
	3	5.37	0.910	28.00
	6	4.83	0.920	28.33
C	0	5.97	0.940	26.37
	3	5.47	0.935	26.00
	6	4.90	0.920	28.60

*values are means of three trials

The temperature of pre-cooked chicken *isaw* during the six-hour hold-on display period remained in the hazard temperature zone for holding foods. The temperature of the test products ranged from 25.33 to 28.33°C. A number of pathogenic and spoilage microorganisms have optimum temperature for survival and multiplication in this temperature range (Eley, 1992).

The physico-chemical properties of the different sauces of chicken *isaw* during the vending operations are shown in Table 2. The sweet sauce was a brown starch-based sauce with sugar, red cayenne, and pepper while the sour sauce had vinegar as the basal medium. The pH readings of the sweet sauce fell within the range of 3.50-4.10. The pH readings became lower as the vending operations reached the 6 h mark. The decreasing trend in pH readings was also observed for the sour sauce, which had a pH range of 2.80-4.17. The decline in pH of the two sauces under ambient conditions may have been caused by acids produced by the contaminating microorganisms. This decline may possibly be caused by the cross-mixing of sauces by dipping grilled *isaw* from one sauce to another. The

Table 2. Physico-chemical properties of chicken *isaw* sauces during street-vending operations*

Sauce	Vendor	Vending time (h)	Physico-chemical tests		
			pH	Aw	Temp (°C)
Sweet	A	0	4.10	0.940	30.02
		3	3.90	0.928	28.99
		6	3.80	0.915	27.87
	B	0	4.07	0.960	29.15
		3	3.70	0.953	28.77
		6	3.50	0.947	27.83
	C	0	3.50	0.955	29.73
		3	3.73	0.950	27.97
		6	3.50	0.930	27.97
Sour	A	0	3.70	0.923	28.02
		3	3.00	0.919	28.60
		6	2.80	0.918	27.40
	B	0	4.10	0.927	31.00
		3	4.23	0.923	33.27
		6	4.17	0.898	34.67
	C	0	3.63	0.955	28.67
		3	3.50	0.948	26.37
		6	3.00	0.898	34.64

*values are means of three trials

lower pH range is conducive to the growth of certain fungi and acid-forming bacteria.

The Aw of the sauces fell within the range of 0.898-0.960 and showed a decreasing trend under hold-on conditions during vending operations. These Aw values of the sauces can very well support the growth of spoilage microorganisms, considering that most bacteria and fungi require optimum Aw of 0.910 and 0.800, respectively (Jay, 1992). Dehydration of the *isaw* resulting from exposure to the environment and proximity to the grilling area may have caused the decreasing trend of Aw readings during the six-hour vending operations.

The temperature of the sauces during the six-hour hold-on display and use under ambient conditions fell in the range of 26.37-34.67°C. The temperature fell within the hazardous range of 7.20-62.8°C that promotes growth of most micro-organisms (Jay, 1992). The kind and the number of microorganisms that might proliferate in the different sauces are limited by the pH and other antimicrobial properties of the ingredients in the sauces.

Microbiological tests

The pre-cooked chicken *isaw* displayed under ambient conditions during the vending operations were shown to have a TPC ranging from 10^5 to 10^8 cfu/g (Table 3). An increasing trend in the number of total aerobic microorganisms was observed in the six-hour vending operations. The critical temperature of storage, Aw, and pH of the test street foods during vending operations were all conducive to the growth of a wide range of microorganisms. It is not unexpected, therefore, to observe an increase in the number of microorganisms in food samples stored at ambient temperature. The intestines of poultry have also been reported to be the primary source of spoilage and pathogenic micro-organisms in deteriorating dressed poultry carcass (Frazier and Westhoff, 1988). The reported acceptable

Table 3. Total plate counts and coliform counts of pre-cooked chicken *isaw* during vending operations

Vendor	Vending time (h)	Microbiological tests	
		TPC (CFU/g)	Coliform (MPN/g)
A	0	2.72×10^6	2.73×10^2
	3	7.74×10^7	1.11×10^3
	6	5.00×10^8	2.40×10^3
B	0	1.91×10^6	8.39×10^2
	3	2.09×10^7	1.61×10^3
	6	2.40×10^7	1.97×10^3
C	0	6.33×10^5	1.08×10^2
	3	6.16×10^7	1.70×10^2
	6	2.80×10^8	1.02×10^3

*values are means of three trials

Table 4. Percent decrease in TPC and coliform counts of chicken *isaw* with grilling

Vendor	Trials	Total Plate Count (cfu/g)		% Decrease	Coliform Count (MPN/g)		% Decrease
		Raw	Cooked		Raw	Cooked	
A	0	$4.24x10^6$	$1.75x10^4$	99.59	$1.75x10^3$	$1.20x10^2$	93.14
	3	$2.70x10^5$	$3.10x10^3$	98.56	$1.03x10^3$	$4.30x10^1$	95.70
	6	$1.23x10^6$	$1.44x10^4$	98.83	$1.03x10^3$	$2.00x10^1$	98.00
			Average	**98.99**			**95.61**
B	0	$6.00x10^6$	$2.84x10^4$	99.52	$2.40x10^3$	$2.00x10^1$	99.04
	3	$3.60x10^5$	$3.14x10^4$	91.25	$1.63x10^3$	$9.50x10^1$	94.17
	6	$1.81x10^6$	$4.48x10^4$	97.52	$3.82x10^2$	$1.50x10^1$	96.06
			Average	**96.10**			**96.42**
C	0	$5.48x10^5$	$3.15x10^4$	94.25	$9.10x10^2$	$2.30x10^1$	97.47
	3	$6.35x10^6$	$6.45x10^4$	98.98	$1.73x10^3$	$9.50\ 10^1$	94.51
	6	$7.15x10^5$	$5.38\ 10^3$	99.24	$2.80x10.^2$	$2.30x10^1$	89.45
			Average	**97.49**			**93.81**

aerobic plate count for raw poultry meat was 10^6/g (Wehr, 1982). The values obtained from the pre-cooked samples sometimes fell outside of this criterion especially for samples stored for over 3 h.

The coliform counts of the pre-cooked chicken *isaw*, likewise, showed a general increasing trend with length of storage. Coliform counts of pre-cooked *isaw* samples fell within the range of 10^2-10^3 MPN/g. Meat animals have large numbers of different types of microorganisms in their intestines. The attainable reference level of hemophilic *Enterobacteriaceae* in the intestines of meat animals is about 10^4 MPN/g (Mossel et al., 1995). The coliform count for poultry meat has been reported to be 10^3 MPN/g (Wehr, 1982). The pre-cooked chicken *isaw* samples have coliform counts at about the same level.

Table 4 shows that grilling of chicken *isaw* over burning charcoal caused a significant decrease in its TPC. The TPC of the cooked *isaw* ranged from 10^3 to 10^4 cfu/g while the coliform counts ranged from 10^1 to 10^2 MPN/g. The temperature of the burning charcoal was effective enough in killing a significant number of microorganisms present in the food samples. The average temperature of the charcoal used for grilling the pre-cooked *isaw* reached up to 234°C (Table 5). However, the internal temperature of the newly cooked *isaw* samples before these were dipped into any of the sauces reached only an average of 51.94°C. This average internal temperature of the cooked chicken *isaw* is still conducive to the survival of spoilage and pathogenic microorganisms even after pre-cooking.

Cooking of food must reach a temperature of about 83.0°C or higher to ensure food safety (Longree and Armbuster, 1996). Some pathogenic microorganisms

Table 5. The temperature of the charcoal and the grilled chicken *isaw*

Trials	Temperature of coal (°C)	Internal temperature of grilled chicken isaw (°C)
1	226.0	51.35
2	235.0	54.50
3	240.0	49.95
Average	234.0	51.94

can not be totally inhibited or inactivated at the average internal temperature reached in grilling chicken *isaw*.

Table 6 shows the TPC and coliform counts of the different sauces used during the six-hour vending operations. The TPC of the sweet sauce at hold-on display or use under ambient conditions during vending operations showed a general increasing trend, ranging from the 10^4 to 10^6 cfu/g. The sour sauce showed lower TPC values. The TPC values of the sauces are above the recommended values for sauces and ketchup set at 10^4 cfu/g (ICMSF, 1986).

The coliform counts of the sweet and the sour sauces ranged from 10^1 to 10^2 MPN/g sample during the six-hour vending operations. Some of these counts are above the normal coliform count set for the sauces, at 10 MPN/g (ICMSF, 1986). The presence of coliform microorganisms in food indicates fecal contamination.

Table 7 shows the summary of results conducted in detecting the presence of pathogenic microorganisms in chicken *isaw* and its sauces. Potential pathogenic microorganisms, such as *Salmonella*, *S. aureus*, and *L. monocytogenes* were present in pre-cooked chicken *isaw* during hold-on display for 6 h under ambient conditions. The washing and pre-cooking of chicken intestines in light brine with vinegar were not sufficient in eliminating the contaminating microorganisms. *Salmonella* and *L. monocytogenes* have been reported to be natural contaminants found in the visceral parts of poultry.

The contamination of *S. aureus* could have been the result of mishandling of vendors as the pre-cooked chicken intestines were skewered using bamboo sticks. The hands and skin of vendors might be considered possible sources of *S. aureus* found in *isaw* because the microorganism forms close and stable association with man and is often found part of the normal microflora of human nose, throat, and skin.

The grilling process was shown to effectively destroy the vegetative cells of *L. monocytogenes* and *S. aureus*. However, grilling of chicken *isaw* was shown to be ineffective in completely inactivating *Salmonella*. This may be attributed to insufficient heating of chicken *isaw* during the grilling process, resulting in a low average internal temperature of 51.94°C. A maximum temperature of ≥ 60°C with heating time of at least > 2 minutes is necessary in order to eliminate *Salmonella* in food.

The sour sauce did not contain the three test pathogens analyzed. The sweet sauce, used as cocktail dips for chicken *isaw* supported the growth of *Salmonella*, but not *S. aureus* and *L. monocytogenes*. The repression of *Salmonella* survival and growth in the sour sauce may be attributed to the sensitivity of this group of microorganisms to organic acidulants like acetic acid (Grau, 1989). Vinegar, being high in acetic acid and as the main ingredient of the test sour sauce, may have

Table 6. Total plate and coliform counts of the different sauces of chicken *isaw* during vending operations

Sauce	Vendor	Vending time (h)	Microbiological tests	
			TPC (CFU/g)	Coliform (MPN/g)
Sweet	A	0	3.72×10^6	2.03×10^1
		3	2.94×10^6	2.03×10^1
		6	3.53×10^6	7.90×10^1
	B	0	1.06×10^4	1.80×10^1
		3	1.08×10^5	3.00×10^1
		6	2.08×10^5	1.98×10^2
	C	0	2.68×10^5	11.93×10^1
		3	1.19×10^6	3.00×10^1
		6	1.07×10^6	7.03×10^1
Sour	A	0	1.03×10^5	4.33×10^1
		3	3.66×10^5	1.27×10^1
		6	7.62×10^3	1.13×10^1
	B	0	7.97×10^3	1.47×10^1
		3	1.77×10^4	3.00×10^1
		6	1.29×10^4	3.67×10^1
	C	0	1.66×10^4	2.33×10^1
		3	2.40×10^5	3.53×10^1
		6	5.11×10^4	8.93×10^1

*values are means of three trials

Table 7. Detection of *Salmonella, Staphylococcus aureus,* and *L. monocytogenes* in chicken *isaw* and its sauces

Sample	Microorganisms		
	Salmonella	*S. aureus*	*L. monocytogenes*
Isaw			
Pre-cooked *isaw*	+	+	+
Cooked *isaw*	+	-	-
Sauces			
Sweet sauce	+	-	-
Sour sauce	-	-	-

+ positive for organism/25 g sample
- negative for organism/25 g sample

been inhibitory to the survival of *Salmonella.*

Table 8 shows the TPC and coliform counts of bamboo skewers and the hand undersurface of a test vendor. The TPC and coliform counts of skewers contained about 10^2 cfu/skewer and 10^1 MPN/skewer, respectively. The TPC and coliform counts of the hand undersurface of the participating vendors were in the range of 10^3-10^4 cfu/cm^2 and 10^1-10^2 MPN/cm^2, respectively. The acceptable standard for total viable counts set for surface contamination as applied for in-use items is <10 cfu/cm^2 (Solberg et al., 1990). Counts >20 cfu/cm^2 are already considered as potentially hazardous.

Table 8. Total plate counts and coliform counts of vendor's hand undersurface and skewers*

Source	Vending time (h)	TPC (CFU/skewer or cm^2 hand surface)	Coliforms (MPN/skewer or cm^2 hand surface)
skewer	0	1.70×10^2	2.76×10^1
	3	3.85×10^2	3.73×10^1
	6	8.70×10^2	5.20×10^1
hand	0	4.55×10^3	5.30×10^1
under-	3	5.28×10^4	7.80×10^1
surface	6	5.82×10^3	10.60×10^2

*values are means of three trials

Hazard analysis and critical control points

The identified hazards and critical control points in the street-vending operations of chicken *isaw* are shown in Fig. 1. The initial contamination of raw chicken intestines, skewers, and the sauces represented a major source of microbial hazards in street-vended grilled *isaw.* Washing tends to decrease the number of microorganisms in the raw chicken intestines. The quality of the water used and the efficiency of washing, however, determined the efficacy of the step in lowering the microbial contamination of the raw material.

Pre-cooking of the chicken intestines in light brine with vinegar again represented a major step by which the microbial flora of the material could be decreased. The concentrations of brine and vinegar and the length of cooking were factors which could determine the effectivity of these steps in lowering the microbial counts of the commodity.

Skewering of the pre-cooked intestine with bamboo skewer was another source of contamination of the chicken *isaw.* The skewers were found to contain a substantial amount of microorganisms that could increase the microbial load of the food. The handling of the food during skewering, likewise, represented a major factor in increasing the microbial load of the product. The hands of the vendors served as vectors in transmitting microorganisms into the food.

The addition of food color in the skewered *isaw* might further increase the number of microorganisms in the commodity. The application of food color on the product could facilitate the cross-contamination between products. Subsequent refrigeration of the prepared pre-cooked samples before these were displayed during vending tended to suppress microbial growth.

Grilling of the *isaw* over live charcoal was the most important step that would actually eliminate microbial contaminants in this commodity. The step was shown to effect >95% inactivation decrease of microbial contaminants, including coliform. However, this step could not totally eliminate *Salmonella* in the grilled intestine. Survival of *Salmonella* was attributed to poor heating of the internal cold point of the product.

The starch-based sweet sauce of chicken *isaw* tended to support the survival of a number of microorganisms, including *Salmonella*. The sour sauce proved to be safer than the sweet sauce. The unhygienic use of the sauces as common cocktail dips represented a major cause of recontamination of the newly grilled chicken *isaw*. Another factor that should be considered in analyzing the microbial hazards of *isaw* is the contamination from the vendors' hands during vending operations. Unavailability of water in the area for handwashing made it difficult for vendors to maintain clean hands necessary for food handling.

The pre-cooking time and temperature of the raw chicken intestine in a solution of light brine and vinegar were identified as CCPs in the vending operations of grilled chicken *isaw*. Likewise, the pH of the cooking solution was considered critical in controlling the microbial safety of the product. The time and temperature during the hold-on display of the sauces and pre-cooked *isaw* at ambient conditions were also among the CCPs for grilled chicken *isaw* vending. The duration of the grilling and the temperature of the coldest point of the pre-cooked *isaw* during grilling were established as significant determinants in the survival of contaminating microorganisms, including those that are potentially pathogenic like *Salmonella*. Finally, the observance of hygiene in the use of the different sauces was considered as a significant parameter in controlling the safety of the product.

SUMMARY AND RECOMMENDATIONS

Street-vending of grilled chicken *isaw* is popular in the Philippines. The affordability of the commodity makes it appealing to the public, but hazardous to a large portion of the population. The unsanitary use of the sauces poses health risks to customers.

Hazards were identified in the street-vending operations of chicken *isaw*. These were based on the observed practices of the participating streetfood vendors operating on UP Diliman campus. Typical food flow of the operations involved pre-cooking of the chicken *isaw*, skewering, application of food colors, grilling, and dipping into sauces. Hazards associated with the street-vending operations of chicken *isaw* included initial contamination present in the raw chicken intestines, contamination from food-contact surfaces during pre-cooking, additional contamination from food colors, and the possible survival of pathogenic microorganisms even after grilling.

One of the critical points identified was the time and temperature conditions during grilling. Proper time and temperature during cooking must be effectively maintained in order to destroy the pathogenic microorganisms present in the chicken intestines. The time and temperature conditions under which the sauces were stored favored the proliferation of contaminating microorganisms.

Salmonella, *L. monocytogenes*, and *S. aureus* were detected initially in the pre-cooked sample. These microorganisms were observed to be inactivated during grilling. The physico-chemical properties of the chicken *isaw* such as the pH, Aw, and temperature provided conducive conditions for the growth of contaminating microorganisms. The presence of coliform microorganisms clearly indicated the fecal contamination of the product. The contaminating microorganisms present in the different sauces were shown to survive conditions during hold-on display of the product. The cross-contamination from the different sauces used as cocktail dips provided additional contamination to the commodity.

A number of recommendations were formulated based on the identified hazards and critical points during the street-vending operations of chicken *isaw*. The chicken *isaw* must be procurred from a known source that supplies only fresh raw material. Only potable water must be used in the cleaning of chicken intestines to avoid further contamination. The intestines must be cleaned in a free flowing water since this is more effective than tub washing. Chicken *isaw* must be boiled in rolling brine with vinegar for at least 10 minutes in order to destroy most vegetative cells of pathogenic microorganisms. Immediate cooling or chilling of the chicken intestine after pre-cooking must be done. The hygienic handling during skewering and use of washed bamboo skewers for pre-cooked *isaw* may prevent the introduction of additional contaminants. Food grade color must be used in the coloring of the chicken *isaw* to enhance its appearance. Prolonged storage of the chicken *isaw* during vending at ambient conditions must

be avoided. Immediate grilling of the food or chilling of the pre-cooked *isaw* should be done to avoid proliferation of microorganisms. The use of dispensers for the sauces may significantly lower the microbial load of the consumable grilled product.

ACKNOWLEDGMENT

Ma. Patricia V. Azanza thanks the Office of Research Coordination of U.P. Diliman for the research grant.

REFERENCES

Abdussalam, M., 1987. Ignorance means risks. In World Health Organization, 5-7.

Bryan, F. L., 1992. Hazard analysis critical control points of street-vended food in the Dominican Republic. *J. Food Protect:* 51, 373-383.

De Guzman, M.P., F. C. Cuaderno, A. U. Mandala, E. V. Castillo, F. L. Castrock, P. A. Alayon, & A. G. Magsaysay, 1994. The Application of streetfoods in schools. San Juan and Las Piñas, as FNRI Seminar Series. 37-38.

Eley, A.R., 1992. Microbial Food Poisoning. London, Chapman and Hall Press: 191 pp.

Frazier, W. C. & D. C. Westhoff, 1988. Food Microbiology. New York, John Wiley and Sons: 210-240.

Handy, M.K., N.D. Burton, W.E. Burton, & W. E. Brown, 1964. Source and portal entry of bacteria found in brined poultry tissue. *Appl. Microbiol.* 12:464-469.

ICMSF, 1986. Microorganisms in Foods, Sampling for Microbilogical Analysis (2nd ed.) Toronto, University of Toronto Press: 358 pp.

Jay, J.M., 1992. Modern Food Microbiology 4th ed. New York, Chapman and Hall Press: 243 pp.

Longree, K. and G. Armbuster, 1996. Quantity Food Sanitation. New York, John Wiley and Sons, Inc.: 347 pp.

Mossel, D. A., J. E. Corry, C.B. Struijk, & R.M. Baird, 1995. Essentials of the Microbiology of Foods. New York, John Wiley and Sons, Inc.: 75-76

Solberg, M., J. J. Buckalew, C.M. Che, D.W. Schatter, & K. O. Oneill, 1990. Microbial safety assurance systems for food service facilities. *J. Food Tech.* 44: 69-72.

Standards Association of Australia, 1986. Australian Standard 1766.2.4. Methods for the microbiological examination of foods - coagulase - positive staphylococci. Sydney, Australia.

_____, 1987. Methods for Dairy Industry. Sydney, Australia.

_____, 1989. Australia Standard 1766.2.5. Methods for the Microbiological Examination of Food - *Salmonellae.* Sydney, Australia.

Sutherland, P.S., 1989. *Listeria monocytogenes*, In K.A. Buckle, J.A. Davey, M.J. Eyles, A.D. Hocking, K.G. Newton & E.J. Stuttard, (eds.) Foodborne Microorganisms of Public Health Significance. NSW, Australia, J. M. Executive Printing Service Pty. Ltd.: 311 pp.

Wehr, H.M., 1982. Attitudes and policies of governmental agencies on microbial criteria for foods - An update. *Food Tech.* 36:45-54, 94.