Food safety knowledge and microbiological hygiene of households in selected areas of Kwa-Zulu Natal, South Africa

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Abstract

This study was conducted to determine the level of food safety knowledge and practices during food handling and preparation at household level in selected areas in KwaZulu-Natal province of South Africa. Fifty households were selected to participate based on their monthly income, age and educational level. Samples of raw foods were randomly collected from the participating households for microbial analyses. Swabs from food contact surfaces were also collected and analyzed for the presence of pathogens. Difference in demographic data regarding food safety knowledge was tested using chi-square and microbial counts were statistically analyzed ($P<0.05$). Knowledge of proper cold storage temperature was found to be inadequate as over 70% of respondents had no idea of their cold storage temperatures. High risk of cross contamination was observed due to improper thawing, packaging of meat with other ready to eat foods and poor food contact material handling. Microbial analyses of raw food samples showed the presence of aerobic spore formers (1.08-1.89 log cfu/mL), anaerobic spore formers (0.29-1.83 log cfu/mL) and *Staphylococcus aureus* (3.31-3.96 log cfu/mL). Contact surfaces were also positive for *Listeria monocytogenes, Salmonella* spp and *Escherichia coli*. Food safety knowledge and proper food handling practices were found to be inadequate in the areas studied and urgent intervention is required to prevent fatal incidences of food borne illnesses.

Introduction

Food contamination has been reported as the cause of death of about 2 million people per year, (Asiegbu *et al.,* 2016). The cases of food borne illnesses in Europe is estimated to be more than five million annually, reflecting the economic losses and risk to humans (Jevšnik, Hlebec and Raspor 2008). Altekruse *et al.* (1999) reported that each year, foodborne diseases affect an estimated 6.5-33 million people in the United States, with medical costs and productivity losses estimated at $9.3 to $12.9 billion dollars. Improper food preparation practices in consumer homes are the main cause of foodborne diseases (Redmond and Griffith 2003). Studies have revealed that a substantial number of consumers demonstrate very poor food handling practices (Redmond and Griffith 2003; Sanlier 2009). It has been suggested that the improvement of consumer food handling behavior could have a beneficial effect on the reduction of risk and the occurrence of foodborne outbreaks (Jevšnik *et al.*, 2008) .

The home is the primary location for foodborne disease outbreaks (Byrd-Bredbenner *et al.* 2013). Although, consumers are concerned about the safety of foods they consume, they generally lack food safety knowledge and skills for good handling and preparation practices of food in their homes (Jevšnik *et al.*, 2008). This confirms a gap in food safety knowledge with a high risk of foodborne outbreaks (Raspor, 2008). Pathogenic microorganisms are able to spread from human hands and food contact surfaces into foods and *vice-versa* (Gorman *et al.*, 2002) and so, it is important that consumers are aware of proper food handling and safety practices in their domestic kitchens.

In a previous study conducted by Kennedy *et al.* (2011) to monitor the transfer of pathogenic microorganisms in a simulated domestic kitchen environment, it was found that cross-contamination of food materials occurred from kitchen utensils such as poorly washed knives, chopping boards and plastic materials. Also, Cunningham *et al.* (2011) who collected surface samples at a food service center, discovered that practice of evaluating the fitness of contact surfaces for food handling and preparation through sight and touch only may not be adequate to adjudge such surface as meeting regulatory requirements.

Raw foods pose a great risk of microbial contamination as some of them are insufficiently cooked before eating. Due to an extended storage period under refrigeration temperatures, some bacteria can grow in them, although at a reduced rate, and this may pose a potential risk to humans when the foods are consumed. Pérez-Rodríguez *et al.* (2010) on the microbiological quality of cooked meat products during slicing and handling at retail outlets found that ready to eat meat products are contaminated during the slicing stage, which leads to several outbreaks, as sliced cooked meats are mostly consumed without a need for prior heating before consumption.

Food safety awareness and knowledge in small and middle income homes around South Africa is recently gaining popularity. Unusan (2007) explained that the educational levels and economic capacities may affect the attitude of consumers towards food safety practices, and this could be a major factor in the level of awareness in homes. Langiano *et al.* (2012) mentioned that lack of correct adherence to food hygiene practices exists in many households and is largely due to errors during food preparation and storage. Many South African consumers depend largely on raw and semi-processed foods and there is a high possibility of cross contamination between these foods and the kitchen surfaces where these foods are processed. Therefore, the major objective of this study was to determine the food safety knowledge within households of selected areas of Kwa-Zulu Natal, South Africa, with a case study on raw meat.

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Materials and Methods

The survey

The study was conducted in three small settlements; Oshabeni, Gcilima, located in Port Shepstone and Danganya located in Durban, both within the Kwa-Zulu Natal Province, South Africa. Data were collected during on-site visit and face-to-face interviews. Ten homes were visited every two weeks during the period of the study and 50 homes were visited in total. All study subjects were 18 years and older and are usually responsible for handling and preparing the food in their households. Well-structured questionnaire was used to obtain all the required information from respondents. The questions were well explained to the respondents and each household was given a copy of the questionnaire to complete during the face-to-face interview. Demographic factors considered in this study include monthly income, age, educational level, gender and race. The questionnaire consisted of 23 questions and was designed in a multi-choice questions and answer format where the respondents had to pick the answers that best suited their practices from the given options. The purpose was to evaluate the food safety knowledge and microbiological hygiene upon food handling and preparation by respondents.

Sampling of foods and food contact surfaces

On each visit for 10 weeks, a mixture of ten different raw food samples were aseptically collected and food contact surfaces swabbed from each household to obtain 50 samples each for raw foods and contact surfaces (Tables 1 and 2). Both wet and dry swabbing techniques were used on surfaces of at least 10 cm square dimension (Ismaïl *et al.,* 2013). The swabbed samples were immediately kept in cooler box containing ice, before laboratory analyses that were conducted the same day. In few cases where samples were not tested the same day, samples were then stored in a refrigerator maintained at 4±2°C, and analyzed later. For raw food, samples of each food item from the lot found within the households were collected into sterile plastic bags and kept in cooler boxes.

Sample preparation

All the media used for sample analyses were purchased from MercK Ltd., Gauteng, South Africa. For sample preparation, 90 mL of buffered peptone water (BPW) was added to ten grams (10g) each of aseptically weighed raw solid food samples and the mixture was macerated using a blender (Stomacher lab-blender 400, BA 6021). Thereafter, serial dilution and enrichments were then done on these samples. Surface swabs collected were also mixed with 10 mL BPW and thoroughly mixed before dilution and enrichment. Quantitative microbial analyses for the following microorganisms were performed on each food sample: aerobic colony count (ACC), enumeration of aerobic and anaerobic spore formers (ASF and ANSF) and *Staphylococcus aureus* using Oxoid media appropriate in each case, while presence tests for *Listeria monocytogenes, Salmonella* spp. and *Escherichia coli* were performed on foods and food contact surfaces.

Aerobic colony count

Serial dilution for foods and surface

Table 1. Occurrence of pathogenic microorganisms on food contact surfaces from different households.

Category	No. of samples	Presence of *L. monocytogenes* (%)	Presence of *Salmonella* (%)	Presence of *E. coli* (%)
Cutting boards	10	1 (10)	0 (0)	5 (50)
Knives	10	4 (40)	1 (10)	3 (30)
Plates	10	0 (0)	1 (10)	3 (30)
Spoons	10	3 (30)	2 (20)	5 (50)
Top bench	10	0 (0)	4 (40)	1 (10)
Total Samples	50	8 (16)	8 (16)	17 (34)

Table 2. Occurrence of pathogenic microorganisms in raw foods collected from different households.

Category	No. of samples	Presence of *L. monocytogenes* (%)	Presence of *Salmonella* (%)	Presence of *E. coli* (%)
Carrots	10	4 (40)	3 (30)	7 (70)
Meat	13	3 (23)	1 (8)	7 (54)
Green pepper	9	1 (11)	1 (11)	4 (44)
Onion	8	2 (25)	2 (25)	3 (38)
Tomato	10	8 (80)	3 (30)	8 (80)
Total Samples	50	18 (36)	9 (21)	29 (57)

Table 3. Microbiological qualities of ready-to-eat products presented in means of ASF, ANSF, ACC and S. aureus (log CFU/mL) collected at household level in different locations.

Category	ASF	ANSF	ACC	*S. aureus*
Carrots	1.63^{a}±3.06	0.85^{b}±1.88	4.87^{c}±2.04	3.97^{d}±3.46
Meat	1.08^{a}±2.29	1.83^{b}±2.95	6.27^{c}±0.24	3.78^{d}±3.78
Green pepper	1.11^{a}±2.37	1.78^{b}±2.88	5.00^{c}±2.66	3.31^{d}±3.51
Onion	1.89^{a}±2.63	0.5^{9b}±1.79	4.93^{c}±2.60	3.96^{d}±3.46
Tomato	1.52^{a}±2.47	1.20^{b}±2.55	4.31^{c}±2.98	3.83^{d}±3.72

ASF: Aerobic spore formers, ANSF: Anaerobic spore formers, ACC: Aerobic colony count. Means with same superscript letters in columns are not significantly different ($P<0.05$).

swab samples were prepared using BPW and 1mL of each diluent was pour-plated with nutrient agar in duplicate and then incubated at 30°C for 72h, as according to South African Standard procedure 4833 (SANS, 2007). Results are reported as log cfu/mL of the sample.

Aerobic and anaerobic spore formers

Spore formers were enumerated according to the guideline procedure MFLP-44 (Health Canada, 1998) for each sample, two test tubes containing 25 mL of sample were heated in a water bath at 75°C for 20 min, one as a temperature control. Serial dilutions were done and pour-plating was done in duplicate. One set of plates inoculated was incubated aerobically at 37°C for 48h while another set of plates was incubated in anaerobic jar (Merck Ltd., Gauteng, South Africa) at 37°C for 48h.

Staphylococcus aureus

The presence of *S. aureus* was determined according to the International Standard procedure 6888-1 (ISO, 1999). About 0.1 mL each of the dilutions was decanted on Baird Parker agar (Oxoid) plates containing egg-yolk tellurite solution. The plates were incubated at 37°C for 24h. The coagulase test was done on typical colonies for *Staphylococcus spp.* confirmation.

Salmonella spp.

Salmonella spp. were determined according to International Standard procedure 6579 (ISO 1993). 25 mL of macerated sample in BPW was further added to 225 mL BPW and incubated at 37°C for 24h. Thereafter, 10 mL of this pre-enriched sample suspension was transferred into 100mL of selenite cystine medium (Oxoid) and incubated at 37°C for 24h. Pure cultures from selenite cysteine agar (Oxoid) were then inoculated in XLD agar (Merck Ltd, Gauteng, South Africa) plates and incubated at 37°C for 24h and pathogen detector assays (3M pathogen detector) were also conducted to confirm the presence of *Salmonella spp*. The results were reported as presence or absence of pathogen in the sample.

L. monocytogenes

L. monocytogenes were detected according International Standard procedure 11290-1 (ISO, 2004), where 1mL sample each of food-BPW and swab-BPW sample was added to 9 mL of half Frazer *Listeria* Selective broth (Fluka) and incubated at 37°C for 48h. A total of 0.1 mL of the half Frazer *Listeria* Selective broth culture was then transferred into a test tube containing 10 mL of full Frazer *Listeria* Selective broth (Fluka) and also incubated at 37°C for 48h. Oxford Listeria Selective agar (Fluka) plates were inoculated with culture from the full Frazer *Listeria* selective broth (Fluka). The plates were placed in anaerobic jar and incubated micro-aerobically at 37°C for 24h and further *Listeria* pathogen detector assay (3M pathogen detector) and Gram staining tests were conducted to confirm the presence of *L.monocytogenes.*

E. coli

The presence of *E. coli* in raw food and swab samples was confirmed using the method described in the guideline procedure MFHPB-19 (Health Canada, 2002). To 9 mL of lauryl sulphate broth (Fluka), 1 mL of food and swab solutions were added and incubated at 37°C for 24h. After incubation, 1 mL of culture mixture was transferred to *E. coli* broth and incubated again at 37°C for 24h. Pathogen detection assays using 3M pathogen detector were conducted on positive *E coli* broths and the results were also reported as presence or absence of pathogen in the sample.

Data analysis

The SPSS 23.0 statistical package was used for all analyses. Differences between the means of microbial counts were evaluated using analyses of variance (ANOVA) at 95% confidence level. Chi-square test was used to analyze the relationships of data obtained from the questionnaires used to assess the food safety knowledge of respondents (Unusan, 2007).

Results

Consumers' demographic characteristics

Fifty respondents were selected based on gender, age, educational level. Most of the respondents interviewed were females (96%) with a few males (4%). The age of many of the respondents ranged between 30-59 years (46%), with educational levels from less than high school (28%) to high school (42%) followed by tertiary level (30%). Sixty-four percent of the entire respondents had a monthly income ranging between 500-4500 South African Rand.

Meat storage at household level

All (100%) respondents stored their fresh meat in cold refrigerators and freezers. About 61% kept their meats unopened, 24% opened and chopped the meat before storing in freezers while 15% left the meat pack open during cold storage. Of all the respondents, 30% kept their meats for a whole month while only 12% consume their meats within 2-3 days. It was gathered that most (72%) respondents had no idea of the temperature of their freezers while 20% assumed that they were in a range of 0°C and below, since it could form ice. Few respondents (about 8%) were fully aware that their freezers were not working properly.

Thawing of meat by consumers at household level

To evaluate the food safety knowledge during thawing of meats at household level, a separate questionnaire was administered. About 40% of the respondents thaw their frozen meat by dipping in tap water, while 28% leave the frozen meat on kitchen surfaces to thaw. A few use microwave ovens (16%) and warm water for thawing (16%). About 26% thawed the whole packet of meat and if the meat thawed was more than required, about 63% of respondents refroze their meats. Also, 24% of respondents usually leave their meat uncovered while refreezing and 30% did not re-freeze. About 7% sometimes re-freeze, as they explained that this was not their usual practice.

Features of meat quality observed by consumers at purchase

Majority (63%) of respondents claimed to purchase meat parts that do not have bones while only 7% usually buy mince-meat/meatballs. Of all factors considered, price of meat has the highest impact (40%) in determining the kind of meat purchased, followed by the appearance and color (36%). About 20% of the respondents usually checked the expiry date before purchasing their meat. Fat content was checked by 3% and only l% of respondents considered both cholesterol content and the brand of meat. Some of the consumers gave multiple responses in this section as they did not only consider one feature to determine whether the meat was safe and of a high quality. Respondents (84%) use grocery bags to convey meat together with other products such as vegetables, fruits and other food items purchased from stalls to their respective homes and only 16% of respondent use separate bags.

Materials and food handling knowledge evaluation at household level

When respondents were asked whether they washed their hands and their chopping utensils before they prepared food, 92% washed their hands and 78% washed their chopping materials before meat processing. 8% did not wash their hands every time they handled food and 20% did not wash their chopping utensils and about 2% wash their chopping utensils but not every time they use them. Most respondents used chopping boards (98%) to cut their food and about

(72%) used the same chopping board to cut both meat and vegetables. 8% of the respondents use warm water only and 8% of them use warm water, soap and/or sanitizer together to wash their hands and chopping materials after use.

Microbiological qualities of raw foods and contact surfaces collected at household level

The results for ACC, ASF, ANSF and *S. aureus* tested on different raw foods are presented in Table 3. The mean values for total counts for ASF ranged from 1.08-1.89 log cfu/mL while 0.59-1.83 log cfu/mL was obtained for ANSF. Also, ACC ranged between log 4.31-6.27 log cfu/mL and 3.31-3.97 log cfu/mL for *S. aureus*. The percentage occurrence of pathogenic microorganisms in all raw foods sampled from all the households in the different locations studied were also presented (Table 1). Up to 80% of the tomato samples from the households investigated were found to be contaminated with *L. monocytogenes* and *E. coli.* Occurrence of pathogenic microorganisms were also confirmed in other food samples. Results the presence of *L. monocytogenes*, *Salmonella spp.,* and *E. coli* on food contact surfaces are as reported (as % positive) in Table 3. No growth of *Salmonella spp.* was observed in chopping boards and no *L. monocytogenes.* was detected on the plates and top benches. Cutting knives were found to harbor *L. monocytogenes* (40%) and about 50% of cutting boards and spoons had *E.coli*.

Discussion

FDA (2002a) suggested that meat could be stored in the purchase polyethene bags in refrigerators and freezers for up to 2 days. Opening and chopping raw meat before cold storage increase the risk of microbial contamination from the environment and contact surfaces, especially since many respondents stored their meats together with other vegetables and foods within the same freezing chamber. A possible reason for this practice could be lack of knowledge of food safety and the attendant risks. Similar trend was also reported by Chapman *et al.* (2010). The poor knowledge of cold storage reported by respondents is in line with a study conducted by Karabudak, Bas and Kiziltan (2008) where up to 60% of his respondents were uncertain of the temperatures of their refrigerator and freezers.

Chi-square test revealed no significant relationship between age, educational level and monthly income with how the meat was kept in the freezer and the duration it was kept in the freezer ($p > 0.05$). However, there was a significant relationship between age and educational level and the temperature range at which the meat was kept in the freezer. It is important that consumers are aware of the storage temperatures capable of inhibiting the growth of pathogenic and spoilage microorganisms, as some microorganisms can grow at temperatures as low 0□C (Karabudak *et al.,* 2008). Most of the younger age range of consumers had better knowledge as to what temperature their meat should be stored in a freezer ($p<0,05$). Storing meat at inappropriate refrigeration or freezing temperatures can hamper domestic food safety (Lazou *et al.,* 2012), as it has been found that many domestic refrigerators operate above the recommended temperatures (Kennedy *et al.,* 2005).

Thawing in running water (warm or cold) and on kitchen counter is improper (Jevšnik *et al.,* 2008; Lazou *et al.,* 2012). Thawing is a slower process than freezing, and some parts of the raw meat are exposed to favourable temperatures for microbial growth, especially when ambient air or running water is used (Leygonie *et al.,* 2012). Also, moisture released from thawing meat is rich in nutrients that could enhance microbial growth. It is essential that hygienic measures be observed while handling meats during thawing and re-freezing. It is recommended that frozen raw meat be thawed by suspending it in its package inside cold water or in the microwave oven (FSIS/CFSAN, 2002).

The separation of raw meat from other food products can help reduce cross-contamination. Also, since travel times of 1 hour and beyond had been found to trigger temperature abuse in frozen products (Jay *et al.,* 1999; Kennedy *et al.,* 2005) , it is important to convey raw meats in cooler boxes or cooling bags to maintain low temperature and reduced microbial activity from the point of purchase to the cold store in households (Jevšnik *et al.,* 2008). Generally, meat samples had the highest microbial counts, as compared to other raw foods tested. This implies that meat could be a major source of contamination for other food samples when stored together within the same refrigerator. Also, high microbial counts obtained in the RTE foods may be due poor irrigation water used for their growth on the farm and poor quality of water in pre-cooling and washing these foods. Ijabadeniyi *et al.* (2011) earlier reported that the quality of water used on the farm for irrigation and produce treatment in South Africa fall short of the WHO standards. The percentage occurrence of pathogenic microorganisms in all the raw foods sampled from all the households in the different locations studied were also presented (Table 1). High pathogenic organism count could be attributed to poor irrigation and cleaning water qualities, poor handling practices from farm to retail stalls and cross contamination by the packaging materials (Ijabadeniyi *et al.,* 2011)

Hygienic hand washing is one which require the use of warm water with soap or detergent, and continuous scrubbing for at least 20 sec (Jay *et al.,* 1999). Worsfold (1997) reported that 66% of consumers do not was their hands before food handling, 41% did not wash their vegetables and up to 60% used the same chopping board for all food items. Some respondents (68%) washed their chopping utensils using warm water and soap, followed by those who use cold water (16%) before use. Eight percent of the respondents used warm water only and 8% of them used warm water, soap and/or sanitizer together. Sanitation of cutting boards before use could be achieved by washing with 5mL chlorine bleach in one quart of water (Karabudak *et al*., 2008). Cross contamination of foods by hand and chopping materials could be avoided if they are properly washed and drained before use.

Microorganisms can be introduced into the contact surfaces by the foods as raw food products, especially meat, can be a carrier of pathogenic microorganisms (Humphrey *et al.,* 2001). High moisture content of raw foods and prolonged contact times could also increase the possibility of contact surface contamination (Pérez-Rodríguez *et al.,* 2010). The presence of similar pathogens on food contact surfaces further suggests their prior contamination by the raw foods. The presence of pathogens on the contact surfaces could also be due to poor hygiene practices in the households studied. Microorganisms can adhere to food contact surfaces and find favorable conditions for their growth (Taché and Carpentier, 2014). Therefore, it is necessary to ensure that surfaces are adequately cleaned, blotted dry and properly stored.

Conclusion

From the results obtained from the survey carried out in this study, we conclude that despite that consumers are concerned about the hygiene of the foods they consume, there is a huge lack of basic food safety knowledge and proper handling practices. The occurrence of pathogenic microorganisms in the raw foods and food contact surfaces tested poses a high risk of food-borne illnesses in the households surveyed. Favorable conditions for microbial proliferation should be avoided during han-

dling, transportation and storage of ready to eat foods. Raw meat poses a high risk of contamination to other foods and should be stored separately. Food contact surfaces should be washed with clean water, detergent and sanitizers and should be properly dried and stored in dry areas before the next use. The relationship found between the ages and educational status of respondents and storage temperature suggests that consumers within the study area should be adequately exposed to trainings on food safety practices. Also, information about good hygiene practices should be made widely available to consumers through print and electronic media.

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