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Assessment of Hygienic Practices and Microbiological Quality of Food in an Institutional Food Service Establishment

Aisha Idris Ali* and Genitha Immanuel

Department of Food Process Engineering, Sam Higginbottom University of Agriculture Technology and Sciences, Allahabad, UP, India

Abstract

Safe food handling in school kitchens is an important practice to protect the students from foodborne illnesses. Bacterial count in prepared food is a key factor in assessing the quality and safety of food. It also reveals the level of hygiene adopted by food handlers in the course of preparation of such foods. A case study research was conducted to examine the food safety knowledge, attitudes and practices of food handlers and bacterial contaminations in food from two women's hostel kitchens at Sam Higginbottom University of Agriculture Technology and Sciences (SHUATS) Allahabad, India. Questionnaires regarding food safety knowledge, attitudes and practices were administered to all the 25 food handlers working at these two kitchens (18 (72%) from old and 7 (28%) from new women's hostel kitchens) through in-person interviews. A total of 72 cooked food samples (36 from each kitchen) were analyzed for evidence of contamination (total aerobic mesophilic bacteria, coliforms, and *Escherichia coli*). The majority of the food handlers did not used good food handling practices and did not practice proper personal hygiene, because majority of them had poor knowledge and attitudes regarding food safety. All the cooked food samples tested had total APC, coliform, and *E. coli* levels higher than acceptable. The study results, therefore, call for stringent supervision and implementation of food safety practices. Periodic trainings on personal hygiene and good food handling practices will play a pivotal role in improving the safety of the prepared meals in these kitchens.

Keywords: Food handlers; Food contamination; Food safety; Coliforms; *E. coli*

Introduction

When food is cooked on a large scale, it may be handled by many individuals and thus increasing the chances of contamination of the final food. Unintended contamination of food during large scale cooking, leading to foodborne disease outbreaks can pose danger to the health of consumers and economic consequence for nations [1-3]. Foodborne related illnesses have increased over the years, and negatively affected the health and economic well-being of many developing nations [4]. The World Health Organization (WHO) states that about 1.8 million persons died from diarrhoeal diseases in 2005, mainly due to the ingestion of contaminated food and drinking water. Food poisoning occurs as a result of consuming food contaminated with microorganisms or their toxins, the contamination arising from inadequate preservation methods, unhygienic handling practices, cross-contamination from food contact surfaces, or from persons harboring the microorganisms in their nares and on the skin [5,6]. Unhygienic practices during food preparation, handling and storage creates the conditions that allows the proliferation and transmission of disease causing organisms such as bacteria, viruses and other foodborne pathogens [7,8]. Additionally, many reported cases of foodborne viral diseases have been attributed to infected food handlers involved in catering services [9]. The knowledge, attitudes and practices of food handlers have been reported in studies from different countries around world [10-15]. This is because a combination of the three factors: knowledge, attitude and practice of food handlers, play dominant role in food safety with regards to food service establishment [16]. However, despite knowledge and awareness of safe food handling methods, several studies have found that food handlers often do not use safe food handling practices, based on observation and microbial food testing [11,17,18].

According to World Health Organization [19], food handling personnel play important role in ensuring food safety throughout the chain of food production and storage. Mishandling and disregard of hygienic measures on the part of the food handlers may enable pathogenic bacteria to come into contact with food and in some cases, survive and multiply in sufficient numbers to cause illness in the consumer. The hands of food service employees can be vectors in the spread of foodborne diseases because of poor personal hygiene or cross contamination. A USA based study suggested that improper food handling practices contribute to about 97% of foodborne illnesses in food services establishments and homes [20]. Foodborne disease is a challenge for both developed and developing countries [21], and are leading cause of illness and death in developing countries [22]. Despite concerted efforts for several decades, foodborne diseases remain a major global public health issue with substantial morbidity and mortality associated with the consumption of contaminated foods [23]. Even in India though no data are available, microbiological food safety hazards are a common and major health hazard taking several lives frequently causing morbidity and mortality. An outbreak of foodborne botulism due to *Clostridium butyricum* affecting 34 students from a residential school in Gujarat was reported in 1996, and the food sample found to be contaminated was *sevu* (crisp made from gram flour) [24]. The measurement of the safety of foods has relied on evaluation of the microbiological quality of foods [23,25]. Bacterial counts in prepared food or water is a key factor in assessing the quality and safety of food, and can reveal the hygiene level adopted by food handlers in the course of preparation of such foods [26]. In a recent review, *E. coli*, *Shigella*, *Salmonella* and *Campylobacter spp.* were the most commonly reported causes of gastrointestinal disease [27], and all have been associated with foodborne disease [28]. However, in developing countries, monitoring

***Corresponding author:** Aisha Idris Ali, Department of Food Process Engineering, Sam Higginbottom University of Agriculture Technology and Sciences, Allahabad-211007, UP, India, Tel: +91-7525944623; E-mail: aishaidrisali@gmail.com

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the microbial safety of foods is not routinely practiced, due to a lack of infrastructure and effective food safety regulations and standards [29]. Foodborne diseases outbreaks have been linked to improper food handling practices at food service establishments [11,21,22,30]. The most commonly reported food preparation practices that contribute to foodborne diseases include poor environmental hygiene, inadequate cooking, contaminated equipment, improper handling temperatures and food from unsafe sources [21,31,32].

Following the frequent complain of stomach pain and diarrhea among students eating from these school kitchens, this study was conducted to test two research hypothesis: (1) the levels of food contamination will be the same in both women's old and new hostel kitchens due to lack of good hygienic practices and (2) the level of total aerobic mesophilic, coliforms and *E. coli* counts in the cooked foods from both kitchens will be above the food safety standard permissible limit due to improper food handling practices which resulted in frequent diarrhea among students eating from these particular kitchens. The objectives of the study were to: describe the food safety knowledge, attitudes and practices of food handlers' in two women's hostel kitchens at a University (SHUATS) Allahabad, India and to evaluate the food contamination levels at these kitchens through microbiological analyses of the cooked foods.

Problem definition

Current statistics on foodborne illnesses in various industrialized countries show that up to 60% of cases may be caused by poor food handling techniques, and by contaminated food served in food service establishments. In 1989, it was estimated that the total cost of bacterial foodborne illness to the United States economy was US $6,777,000,000. Hence it is a burden on economy also. In developing countries, the effect on economic activity and development can only be far more severe [1].

Materials and Methods

Study design

A case study involving two kitchens at Sam Higginbottom University of Agriculture Technology and Sciences (SHUATS) Allahabad, India was conducted between January to June 2017. The kitchen located at the women's old hostel is the old kitchen, while the one at the new women's hostel is the new kitchen. The school operates full-time and serve food for breakfast, lunch and dinner. All the 25 food handlers working in these two kitchens were involved in the study (18 were from the old and 7 from the new hostel kitchens). The total number of students served by these kitchens is 610. Of these students, 400 eat from the old kitchen, while 210 eat from the new kitchen. Food samples, consisting of all the cooked foods served, at the time of sampling, were randomly collected by the researcher from both kitchens during the study period. The design of the study consisted of three sections. The first section was to observe food safety practices and personal hygiene of the food handlers. The second section was designed to evaluate food safety knowledge attitudes and practices of food handlers. Finally, the third section dealt with the assessment of microbiological quality of the cooked food samples collected from these kitchens.

Data collection

Face-to-face interviews were conducted to collect demographic information of the food handlers (Table 1), information on food handlers' knowledge about food safety, attitudes and practices through a semi-structured questionnaire through in-person interviews by the researcher using questions adapted from some of the previous works [10,33,34].

Parameter	Specification	Number (n)	%
Kitchen type	Old hostel kitchen	18	72
	New hostel kitchen	7	28
Role	Manager	2	8
	Head cook	0	0
	Cooks	10	40
	Servers	13	52
Age of Respondents	Below 19 years	0	0
	19-25 years	0	0
	25-40 years	20	80
	Above 40 years	5	20
Gender	Male	8	32
	Female	17	68
Educational level	None	16	64
	Primary	3	12
	Secondary	2	8
	Tertiary	4	16
Acquisition of knowledge on food preparation	Observation	16	64
	Training	0	0
	Trial and error	4	16
	Taught by parents	5	20
Food service industry experience	1 year	5	20
	2-5 years	17	68
	5-10 years	3	12
	Above 10 years	0	0

Table 1: Characteristics of study respondents from old and new hostel kitchens (n=25).

The section of the questionnaire dealing with food safety knowledge (Table 2, Section A) comprised of 25 questions with three possible answers; "yes", "no", and "do not know". A scale ranging between 0 and 25 (representing the total number of questions on food safety knowledge) was used to evaluate the overall food safety knowledge of the food handlers. Food handlers that obtain total score ≤ 15 points were considered to have "insufficient" knowledge and those that had scores ≥ 16 points (≥ 64% accuracy) were considered to have "good" knowledge of food safety.

The attitudes section of the questionnaire (Table 2, Section B) comprised of 12 questions with three possible answers; "yes", "no", and "do not know". Food handlers that answered 7 or fewer questions correctly were considered to have "insufficient" understanding whereas handlers that answered 8 or more questions correctly were considered to have "good" understanding.

In section which dealt with food hygiene practices (Table 2, Section C), the good hygienic practices of respondents were assessed and evaluated based on self-reporting of personal hygiene, and observation of other safe food handling practices. The section had 10 questions with two possible responses; "yes" and "no". Each correct practice reported scored one (1) point. For evaluation, a score ≥ 70% (n=7) by an individual respondent was considered as having "good" food hygiene practice. All responses regarding the practices were validated by the researcher's observations of the kitchens and respondents, and responses were corrected by the researcher in situations where observations did not tally with the responses (e.g., where they indicated they do not eat, drink or smoke while handling food).

Parameter	Response % (n)		
	Yes	No	Don't know
Food Safety Knowledge of Food Handlers (Section A)			
1. Washing hands before handling food reduces the risk of food contamination	8.0 (2)	0.0 (0)	92.0 (23)
2. Using gloves while handling food reduces the risk of food contamination	4.0 (1)	0.0 (0)	96.0 (24)
3. Proper cleaning and sanitization of utensils increase the risk of food contamination	0.0 (0)	12.0 (3)	88.0 (22)
4. Eating and drinking during food handling increase the risk of food contamination	0.0 (0)	0.0 (0)	100 (25)
5. Food prepared in advance reduces the risk of food contamination	0.0 (0)	0.0 (0)	100 (25)
6. Reheating cooked foods can contribute to food contamination	0.0 (0)	0.0 (0)	100 (25)
7. Children, healthy adults, pregnant women and older individuals are at equal risk for food poisoning	0.0 (0)	0.0 (0)	100 (25)
8. Typhoid fever can be transmitted by food	0.0 (0)	0.0 (0)	100 (25)
9. Bloody diarrhoea can be transmitted by food	0.0 (0)	0.0 (0)	100 (25)
10. Salmonella is among the food-borne pathogens	0.0 (0)	0.0 (0)	100 (25)
11. Hepatitis A virus is among the foodborne pathogens	0.0 (0)	0.0 (0)	100 (25)
12. Staphylococcus is among the foodborne pathogens	0.0 (0)	0.0 (0)	100 (25)
13. Raw and cooked foods should be kept separate	4.0 (1)	0.0 (0)	96.0 (24)
14. Vegetables can be chopped on the same chopping board used to chop raw meat	0.0 (0)	0.0 (0)	100 (25)
15. Food contamination risk can be reduced by knowing fridge temperature	0.0 (0)	0.0 (0)	100 (25)
16. Improper cooking of food causes foodborne illnesses	4.0 (1)	0.0 (0)	96.0 (24)
17. Improper food storage causes health hazards	4.0 (1)	0.0 (0)	96.0 (24)
18. Microbes are on the skin, in the nose and mouth of healthy food handlers	4.0 (1)	0.0 (0)	96.0 (24)
19. Cross contamination is when microorganisms from a contaminated food are transferred by the food handler's hands or kitchen utensils to another food	0.0 (0)	0.0 (0)	100 (25)
20. Freezing kills all the bacteria that may cause food-borne illness	0.0 (0)	0.0 (0)	100 (25)
21. The correct temperature for storing perishable foods is °C	0.0 (0)	0.0 (0)	100 (25)
22. Hot, ready-to-eat food should be kept at a temperature of 65°C	0.0 (0)	0.0 (0)	100 (25)
23. Contaminated foods always have some change in colour, odour or taste	0.0 (0)	0.0 (0)	100 (25)
24. Raw vegetables are at higher risk of contamination than undercooked beef	16.0 (4)	0.0 (0)	84.0 (21)
25. During infectious disease of the skin, it is necessary to take leave from work	8.0 (2)	0.0 (0)	92.0 (23)
Food safety attitudes of food handlers (Section B)	**Yes**	**No**	**Don't know**
1. Well-cooked foods are free of contamination	4.0 (1)	0.0 (0)	96.0 (24)
2. Proper hand hygiene can prevent food-borne diseases	8.0 (2)	0.0 (0)	92.0 (23)
3. Raw and cooked foods should be stored separately to reduce the risk of food contamination	0.0 (0)	0.0 (0)	100 (25)
4. It is necessary to check the temperature of refrigerators/freezers periodically to reduce the risk of food contamination.	0.0 (0)	0.0 (0)	100 (25)
5. The health status of workers should be evaluated before employment	4.0 (1)	0.0 (0)	96.0 (24)
6. Wearing masks is an important practice to reduce the risk of food contamination	4.0 (1)	0.0 (0)	96.0 (24)
7. Wearing gloves is an important practice to reduce the risk of food contamination	4.0 (1)	0.0 (0)	96.0 (24)
8. Wearing hair restraints and clean cloths/uniform is an important practice to reduce the risk of food contamination	4.0 (1)	0.0 (0)	96.0 (24)
9. Long and painted fingernails could contaminate food with foodborne pathogens	4.0 (1)	0.0 (0)	96.0 (24)
10. Food handlers can be a source of foodborne outbreaks	0.00 (0)	0.00 (0)	100 (25)
11. Knives and cutting boards should be properly sanitized to prevent cross contamination	0.00 (0)	0.00 (0)	100 (25)
12. Food handlers with abrasions or cuts on their hands should not handle ready-to-eat food	0.00 (0)	0.00 (0)	100 (25)
Food safety practices of food handlers (Section C)	**Yes**	**No**	
1. Do you use gloves during the distribution of ready-to-eat food?	0.00 (0)	100 (25)	
2. Do you wear an apron while working?	4.0 (1)	96.0 (24)	
3. Do you wear a cap/hair restraint while working?	4.0 (1)	96.0 (24)	
4. Do you wear a mask when you distribute unwrapped foods?	0.00 (0)	100 (25)	
5. Do you wash your hands properly before touching raw foods?	12.0 (3)	88.0 (22)	
6. Do you wash your hands properly after touching raw foods?	12.0 (3)	88.0 (22)	
7. Do you eat, drink or smoke in your work place?	0.00 (0)	100 (25)	
8. Do you wear nail polish when handling food?	68.0 (17)	32.0 (8)	
9. Do you use cutting boards of different colours or do you sanitize a cutting board between preparation of raw foods and cooked foods?	0.00 (0)	100 (25)	
10. Do you properly clean the food storage area before storing new products?	8.0 (2)	92.0 (23)	

Table 2: Food safety knowledge, attitudes and practices of food handlers (n=25).

Food samples collection

Cooked food samples were randomly collected by the researcher from the study kitchens at serving time. The samples obtained from the same kitchens on different days were considered different samples. Approximately 250 to 500 g of food was collected and sealed in sterile stomacher bags, placed in cool boxes. Each sample was properly identified with a number code, subject name and food type, and immediately transported to the microbiological laboratory of food process engineering department, Sam Higginbottom University of Agriculture Technology and Sciences (SHUATS), Allahabad. Samples were processed within 2 hours of collection.

Meals

A total of 72 cooked food samples (36 from each kitchen) were collected. The foods collected from both kitchens were Stir-fried noodles (*Chowmein*), Flattened rice (*Poha*), Potato-based mixed vegetable curry (*Pav Bhaji*), Lentil-based vegetable stew (*Sambhar*), and Indian cottage cheese soup (*Paneer soup*). The samples were collected immediately before or during the distribution of the food to the students. (These meals were cooked from scratch in these kitchens not pre-prepared meals and heated on-site).

Microbiological analyses

The contamination of food was measured by total aerobic mesophilic bacteria plate counts (APC), enumeration of *Escherichia coli* (*E. coli*) and total coliforms. A 25-g sample was collected from each food sample, and were homogenized in 255 ml of sterile buffered peptone water. Each sample was divided into two, and each sub-sample was placed in sterile stomacher bags and homogenized using a pulsifier. After homogenization, each sub-sample was divided into two, and serial 10-fold dilutions were made, up to a certain number of dilutions [35]. Selected dilutions of the food samples were mixed by vortexing, and inoculations were made within 25 minutes of processing, using method adapted from Downes and Ito [36].

For total aerobic mesophilic bacteria (APC) counts, 0.1 ml of the processed food samples of specified dilutions were inoculated on to sterile Plate Count Agar (HiMedia Laboratories, India), using surface spread method, and incubated for 24 h at 37°C [35,37]. After incubation, plates containing 25-250 colonies were selected for counting. Counts obtained were characterized by the reciprocal of the dilution factors used, and additionally by 10. The bacteria population was expressed as a number of colony forming units per gram (CFU/g). In total coliforms and *E. coli* processing, 0.1 ml of the processed food samples of specified dilutions were inoculated on to Chromocult coliform agar (Merck, Germany), a selective indicator medium for the enumeration of *E. coli* and other coliforms. After incubation at 37°C for 24 h, dark blue colonies were classified as *E. coli,* while pink colonies were classified as other coliforms [38,39]. Gram staining was carried out on suspected *E. coli* colonies, and all cultures with gram-negative short rods were biochemically confirmed as *E. coli* using the IMVIC tests [36].

Statistical analyses

All the mean bacterial counts per meal/food were transformed into standard form for statistical analysis. The targeted results were the microbiological quality status of food prepared from each kitchen. For both kitchens, using cut-points for microbiological safety [40], foods were classified as safe if the mean APC of the meals was less than 100,000 CFU/g, and mean counts for coliforms and *E. coli* respectively were less than 100 CFU/g. The statistical analysis was conducted using XLSTAT 2017 Version. The total mean count for APC, *E. coli* and coliform per each food sample from both kitchens were statistically analyzed using two-tailed t test to assess the difference in the mean bacterial counts per food from both kitchens to determine whether there is significant difference or not. The significance of the results was judged with the help of P value at 5% level of significance, if the computed P value is greater than the significance level alpha at 5% level of significance, it means there is no significant difference between the total mean bacterial counts of the same food types from the two different kitchens, otherwise, there is significant difference.

Results

Characteristics of study respondents from old and new hostel kitchens

The interview was conducted for all the twenty-five respondents working in both kitchens (18 from old and 7 from the new women's hostel kitchens) of Sam Higginbottom University of Agriculture Technology and Sciences Allahabad, India (Table 1). Out of the 25 individual respondents in this study, 68% (n=17) were found to be females and 32% (n=8) were male. Twenty (n=20) 80% out of the 25 respondents were between 25 to 40 years of age, and had worked in the food service establishment for more than 4 years. Sixteen (n=16) 64% of the individual respondents respectively in this study did not have any formal education and acquired their food preparation knowledge through observation. Similarly, none of the food handlers 100% (n=25) had attended any specific training for food handling.

Food safety knowledge of food handlers

In our study, the food handlers were not knowledgeable about hygiene practices, cleaning and sanitation procedures (Table 2, Section A). Majority of the food handlers in this study were not aware of the critical role of general sanitary practices in the work place, such as frequent and proper hand washing at work place (92% didn't know), using gloves 96% (didn't know) and proper cleaning and sanitization of utensils 88% (didn't know). Regarding foodborne illness transmission, all the food handlers (100%) did not know that typhoid fever, bloody diarrhoea can be transmitted by food, and they all (100%) didn't know that salmonella and hepatitis A are foodborne pathogens. Over ninety per cent (90%) of the food handlers did not know that taking leave from work in periods of infectious skin disease was necessary. Additionally, 96% did not know that microbes can be found in the skin, mouth and nose of healthy food handlers. On the other hand, all the food handlers (100%) had no knowledge on time-temperature abuse and its effect on food safety.

Food safety attitudes of food handlers

A reduction in the incidence of foodborne illnesses is strongly influenced by attitudes of food handlers towards food safety. Table 2 (Section B) shows the attitudes of the food handlers towards the prevention and control of foodborne diseases. Ninety-six per cent (96%) of the food handlers did not know that wearing of masks, hair restraints, hand gloves and clean cloth/uniform respectively can minimize the risk of food contamination, which is considered a negative attitude reported by majority of our respondents. Similarly, all of the respondents 100% did not know that knives and cutting boards should be properly sanitised to prevent cross contamination of foods. All of the respondents did not know that individuals with abrasions or cuts on their fingers or hands should not touch unwrap foods (100%). Majority of the food handlers (96%) were not aware that foods should not be handled with long and painted fingernails and that the health status of workers should be evaluated before employment. Respondents (100%)

	Old kitchen			New kitchen		
Food samples	**Total aerobic plate count (mean and (SD)* per food)**	**Coliform count (mean and (SD)* per food)**	***E. coli* counts (mean and (SD)* per food)**	**Total aerobic plate count (mean and (SD)* per food)**	**Coliform count (mean and (SD)* per food)**	***E. coli* counts (mean and (SD)* per food)**
Stir-fried noodles (*chowmein*)	4.6×10^6 (1.0×10^5)* a	9.8×10^3 (4.4×10^2)* a	7.8×10^3 (3.5×10^2)* a	4.3×10^6 (1.6×10^5)* a	9.2×10^3 (7.6×10^2)* a	7.6×10^3 (3.5×10^2)* a
Flattened rice (*poha*)	3.9×10^6 (4.4×10^5)* b	9.1×10^3 (9.7×10^2)* b	7.5×10^3 (3.2×10^2)* b	3.6×10^6 (3.4×10^5)* b	8.3×10^3 (8.8×10^2)* b	7.2×10^3 (2.2×10^2)* b
Potato-based mixed vegetable curry (*pav bhaji*)	3.5×10^6 (4.4×10^5)* c	9.0×10^3 (9.5×10^2)* c	7.3×10^3 (1.4×10^2)* c	3.4×10^6 (3.6×10^5)* c	8.8×10^3 (9.9×10^2)* c	7.0×10^3 (1.5×10^2)* c
Lentil-based vegetable stew (*Sambhar*)	3.6×10^6 (4.3×10^5)* d	8.8×10^3 (8.6×10^2)* d	7.0×10^3 (1.3×10^2)* d	3.4×10^6 (2.8×10^5)* d	8.5×10^3 (8.4×10^2)* d	6.8×10^3 (2.5×10^2)* d
Mixed rice dish (*veg. biryani*)	4.5×10^6 (9.8×10^4)* e	9.6×10^3 (4.7×10^2)* e	7.7×10^3 (1.6×10^2)* e	4.3×10^6 (1.1×10^5)* e	9.4×10^3 (5.7×10^2)* e	7.5×10^3 (3.1×10^2)* e
Indian cottage cheese soup (*paneer* soup)	3.0×10^6 (5.5×10^5)* f	8.8×10^3 (6.9×10^2)* f	6.9×10^3 (1.2×10^2)* f	2.8×10^6 (5.6×10^5)* f	8.6×10^3 (5.5×10^2)* f	6.5×10^3 (2.4×10^2)* f
[a-f] Values with same alphabets across the rows are for same foods from the two different kitchens; (SD)*=Standard deviation Note: Both kitchens serve the same menu, but not on same day.						

Table 3: Mean and standard deviation of microbial populations of the cooked food samples (CFU/g) from old and new kitchens.

did not know if it is necessary to check temperatures of refrigerators and freezers periodically. The general attitudes of food handlers towards food safety in this study is unsatisfactory.

Food safety practices of the food handlers

In assessing the food safety practices of the food handlers (Table 2, Section C), 100% of the food handlers reported that they do not use gloves when distributing ready-to-eat or unpackaged food. Majority of the food handlers 96% (n=24) did not use apron or hair restraints during food handling. Additionally, 100% of the respondents were observed eating and drinking during food handing (including chewing dried ground tobacco leaves and smoking), and did not wear mask when distributing ready-to-eat food.

Microbiological analysis of cooked foods

Out of the 72 meal samples analyzed in this study, of which 36 (50%) each were collected from the old and new hostel kitchens respectively, aerobic mesophilic bacteria, coliform and *E. coli* were detected in all the samples. The mean bacterial population of the food samples analyzed is presented in Table 3. In old kitchen, the mean total aerobic plate count ranged from 3.0×10^6 for Indian cottage cheese soup (*paneer* soup) to 4.6×10^6 for stir-fried noodles (*chowmein*). The mean total coliform counts ranged from 8.8×10^3 for lentil-based vegetable stew (*sambhar*) and Indian cottage cheese soup (*paneer* soup) respectively to 9.8×10^3 for stir-fried noodles (*chowmein*). The mean total *E. coli* counts ranged from 6.5×10^3 for Indian cottage cheese soup (*paneer* soup) to 7.6×10^3 for stir-fried noodles (*chowmein*) (Table 3). Also reveal that in new kitchen the mean total aerobic plate count ranged from 2.8×10^6 for Indian cottage cheese soup (*paneer* soup) to 4.3×10^6 for stir-fried noodles (*chowmein*). The mean total coliform counts ranged from 8.3×10^3 for flattened rice (*poha*) to 9.2×10^3 for stir-fried noodles (*chowmein*). The mean total *E. coli* counts ranged from 6.5×10^3 for Indian cottage cheese soup (*paneer* soup) to 7.6×10^3 for stir-fried noodles (*chowmein*), there was no significant difference in levels of contamination of foods from the two kitchens. Using the APC cut point of 100, 000 CFU/g, all the foods from both kitchens were found to have unacceptable high APC levels. Both kitchens prepare and served foods in violation of food safety standards. Similarly, using a cut point of 100 CFU/g for food safety, all food samples from both kitchens were found to have an unacceptable coliforms and *E. coli* levels. Statistically, there was no significant difference ($P > 0.05$) in the level of bacterial contamination between the food samples from both kitchens using two-tailed t-test.

Typically, for foods like stir-fried noodles (*chowmein*), mixed rice dish (*veg. biryani*), potato-based mixed vegetable curry (*pav bhaji*) and lentil-based vegetable stew (*sambhar*), large quantity of raw vegetables (which include cabbage, carrot, capsicum, onions, tomato, cauliflower, garlic) were added at the end of the cooking process and therefore were only exposed to mild heat. Additionally, for Potato-based mixed vegetable curry (*pav bhaji*) and lentil-based vegetable stew (*sambhar*) raw coriander leaves were chopped and added directly to these ready-to-eat foods (prior to serving). For Flattened rice (*poha*), the ingredients which include peanuts, green peas and curry leaves were only exposed to mild heat also. Similarly, for Indian cottage cheese soup (*paneer* soup), the cheese is at the end of the food preparation and therefore is not exposed to intense heat and is also garnish with raw coriander leaves after cooking, prior to serving.

Discussion

Characteristics of study respondents from old and new hostel kitchens

This research provides significant information regarding the level of knowledge, attitudes, and practices in food safety of food handlers and the level of bacterial contamination in all the cooked food samples collected. The results of this investigation need serious intervention and urgent attention. None of the food handlers 100% (n=25) had attended any specific training for food handling. In several studies, food service workers that received training had better hygiene scores and safe food handling practices than those that did not receive training [11,17,41,42]. This reveals that periodic trainings for the food handlers in this study will be of great importance towards safe food handling. Sixteen (n=16) 64% of the individual respondents in this study did not have any formal education. Higher levels of education have been associated with better food safety knowledge awareness, and better sanitary conditions in other studies [18,42], and a study of the environmental hygiene of food service outlets were significantly associated with the age and educational level of operators [43]. A study in India indicated that food handling practices was related with educational status of food handlers [44]. A remarkable positive influence on food hygiene relies on education and

training given to employees by the food service establishments. A study by Isara and Isah [45] described that experience and knowledge on food hygiene of food handlers were associated with good food hygiene practices. The result of the present study revealed an urgent need to conduct a food safety awareness training for food handlers. And it is necessary to evaluate the impact of the knowledge acquired in the food safety training to ensure its effectiveness.

Food safety knowledge of food handlers

In our study, majority of the food handlers were not knowledgeable about hygiene practices, cleaning and sanitation procedures (Table 2, Section B). Eighty-four per cent 84% (n=21) and 80% (n=20) of the respondents didn't know that washing hands before handling food and wearing gloves respectively, proper cleaning and sanitization of utensils (88% did not know) reduces the risk of food contamination. Lack of awareness of such important hygienic procedures by majority of our respondents is very inappropriate. Other studies have found that foods that have been properly prepared can become contaminated when handled by unwashed hands [26,46]. Proper hand washing by food handlers has been reported to significantly decrease the threat of diarrheal diseases in child care facilities [47] and can therefore be encouraged as it could similarly help to minimize the risk of diarrhea and other foodborne diseases in similar facilities. Therefore, it is very important to combine proper hand washing with the wearing of gloves and other hygienic practices in order to minimize the risk of contamination during food handling [48].

Regarding foodborne disease transmission, all the respondents (100%) did not know that hepatitis A and *salmonella* respectively are foodborne pathogens. Similarly, all the respondents (100%) did not know that diarrhoea and typhoid fever can be transmitted by food. These results support recently published work where majority of the respondents did not know if *salmonella*, hepatitis A and B viruses and staphylococcus caused foodborne diseases [10,49]. Over ninety per cent (90%) of the respondents did not know that taking leave from work in periods of infectious skin disease was necessary. Food may be contaminated with harmful bacteria, either directly by an infected food handler, or indirectly through contact with a food contact surface that has been contaminated by an infected food handler. Foods which will not be cooked before being eaten are of greater risk because cooking is a process that would kill many of the bacteria present [50]. Additionally, 96% of the food handlers did not know that microbes can be found on the skin, and in the mouth and nose of healthy looking individuals.

All the food handlers 100% (n=25) did not know that eating, drinking, smoking/chewing tobacco leaves during food handling increase the risk of food contamination However, a number of food-handlers who indicated that they did not eat, smoke or chew tobacco were observed by the researcher eating, smoking and chewing dried ground tobacco leaves while handling food, suggesting that the percentage of food handlers who eat, smoke and chew dried ground tobacco leaves while working was under-reported, and their percentage was corrected based on the researcher's observation. Smoking transfer contaminants from mouth to hands and cigarettes emit particles that contribute to food contamination [51]. On the other hand, all food handlers (100%) were not familiar with time and temperature abuse and its effect on food safety. Improper handling of food, including the abuse of time-temperature, account for most foodborne disease outbreak [52]. In this study food handlers had no knowledge of time-temperature controls. This result is supported by others Bas et al. and Webb and Morancie [11,53] whose report show that knowledge of critical temperatures was insufficient amongst food handlers. Similar finding on the lack of adequate knowledge on temperature controls by food handlers have also been reported from different countries [54-56]. Improper practices responsible for microbial foodborne illnesses have been well documented, and typically involved cross-contamination of raw and cooked food, inadequate cooking, and storage at inappropriate temperatures [57].

Food safety attitudes of food handlers

A reduction in the incidence of foodborne illnesses is strongly influenced by the attitudes of food handlers towards food safety. Thus, there is a strong linkage between positive behaviour, attitudes and education of food handlers in maintaining safe food handling practices [20]. Table 2 (Section B) shows the attitudes of food handlers towards the prevention and control of foodborne diseases. Majority of the respondents 96% (n=24) did not know that wearing of masks, hair restraints, and clean cloth/uniform and hand gloves can minimize the risk of food contamination which is considered a negative attitude reported by majority of our respondents. Dirty clothing may carry pathogens that cause foodborne illness. These pathogens can be transferred from clothing to the hands and to the food being prepared [58]. Similarly, all of the respondents 100% (n=25) did not know that knives and cutting boards should be properly sanitised to prevent cross contamination of foods, and that individuals with abrasions or cuts on their fingers or hands should not touch unwrap foods. Majority of the food handlers were not aware that foods should not be handled with long and painted finger nails 96% (n=24). The general attitudes of food handlers towards food safety in this study is unsatisfactory.

Majority of the food handlers 92% (n=23) did not know that checking fridge temperature reduces food contamination risk. Eighty per cent (n=20) of the food handlers did not know that the health status of the food handlers should be assessed prior to employment. A study reported that 47% of food service chefs and managers had a lack of awareness that sick persons can spread foodborne illness [42]. The health status of these food handlers could have serious implications for food safety. Food handlers themselves may be sources of organisms either during the course of gastrointestinal illness or during and after convalescence, when they no longer have symptoms, and should be excluded from work until they have fully recovered from the illness [59,60].

Food safety practices of food handlers

In assessing the food safety practices of the food handlers, 100% (n=25) of the food handlers reported that they do not use gloves when distributing ready-to-eat food. Transferring microbes from human hands has been reported as a potential cross-contamination route [61]. In fact, scientific studies report that hand-contact surfaces are more likely to be contaminated than food-contact surfaces [62]. The serving utensils are kept on bare floor of the serving area, and back into the ready-to-eat food without washing during serving (based on researcher's observation). The retention of bacteria on food-contact surfaces increases the risk of cross-contamination of food with these microorganisms [63]. Also, the researcher observed that the same utensils used for preparing raw materials were used to handle cooked food. All the food handlers 100% (n=25) eat, drink, chew dried ground tobacco leaves and smoke (male) during food handing. Small droplets of saliva can contain thousands of pathogens. While eating, drinking, smoking and chewing tobacco, saliva can be transferred to hands, or directly to food being handled [58], 92% (n=23) of the food handlers come to work while having cold (based on observation). All the female food handlers 68% (n=17) were found using fingernail polish while

handling the food. According to WHO [58] nail polish can flake off into food and hides dirt. Some food handlers were observed handling food while having cuts on their fingers, and 100% (n=25) of them did not know that food handlers with cuts on their fingers should not touch ready-to-eat food. Bacteria that causes foodborne illnesses can often infect open cuts, and can be transferred to the food.

Majority of the individual respondents do not frequently wash their hands before and after food preparation. Food handlers who do not practice proper personal hygiene, including hand washing at appropriate times and using appropriate hand-washing methods, can contaminate foods with organisms from the gastrointestinal tract [64]. Insufficient and inadequate hand washing by employees in retail food service establishments is well known contributing factor to foodborne illnesses [65]. Research on the prevalence of hand washing and glove use in food service establishments indicates that these hand hygiene practices do not occur as often as they should, because food workers have reported that they sometimes or often do not wash their hands and/or wear gloves when they should [66]. According to Allwood et al. [67] it is generally accepted that the hands of food handlers are an important vehicle of food cross-contamination. All the respondents revealed that they were not aware of the dangers of cross contamination during food preparation 100% (n=25). In this study researcher has observed that one single table (in each kitchen) was used for chopping fresh vegetables, preparation of *chapati*, *puree* and other foods, and after food preparation, these tables are daily swept and mopped with the same broom and mop used for cleaning the dining hall and kitchen floors and the next food preparation continues on the same table (this particular type of cross contamination is a daily routine by the food handlers in this study). Pathogens can be transferred from one surface or food to another. The hands of food handlers can serve as vectors in the spread of foodborne diseases due to poor personal hygiene or cross contamination [11,68]. Cross-contamination is the main reason for many foodborne illness outbreaks. Cross-contamination among food and food contact surfaces can lead to serious health risks like food poisoning or unintended exposure to food allergens. Chopping boards can be an easy place for cross-contamination to occur. Placing ready-to-eat foods such as fresh produce on a surface that held raw meat, poultry, seafood or eggs can spread harmful bacteria. Kitchen utensils and cutting boards also are key cross contamination routes [69]. In fact, research in the UK suggests that 14% of all foodborne illnesses may be due to inadequately cleaned cutting boards and knives [70]. Majority of the individual respondents in this study performed very poorly in important food safety and hygiene practices because they were not aware of the importance of safe food handling and their personal responsibility towards food safety. This had been proved by the study of Ababio and Lovatt [41]. The role of food workers in foodborne outbreaks has been clearly demonstrated by Todd et al. [71] who pointed out that 25% of reported outbreaks are caused by inadequate handling and food preparation practices.

Microbiological safety of cooked food samples

In this study, all the food samples tested had APC, total coliform and *E. coli* CFU/g counts higher than the acceptable levels, which indicates a great need for improvement in safe food handling practices at these kitchens. RTE foods do not need to be reheated before consumption. A high APC, coliforms, or *E. coli* counts suggests contamination resulted from inappropriate processing, incomplete heating, or secondary contamination via contact with contaminated equipment such as chopping boards, knives, and serving wares, etc. Additionally, the presence of *E. coli* in RTE food products indicates the possibility of secondary contamination, coliform on RTE food products reflected the recontamination caused by secondary processing and poor personal hygiene. It is practical to employ Good Hygiene Practices to minimize, if not eliminate, the risk posed by secondary contamination [72]. The high level of contamination of these foods analysed in this study could be associated to the fact that the vegetables and other ingredients added to these foods were at the end of food preparation and therefore were only exposed to mild heat and the ones added to garnish the food were not heat-treated. Also, the serving utensils were carelessly kept on the bare floor of the serving area at the time of serving, and back into the ready-to-eat food when the need arises without washing. Similarly, several risk factors related to the food service environment contribute to occurrence of foodborne illness: poor personal hygiene, inadequate sanitization of surfaces or equipment, cross contamination of prepared food with contaminated ingredients and inadequate temperature control [73,74]. Food handling personnel play important role in ensuring food safety throughout the chain of food production, processing, storage and preparation. Mishandling and disregard to hygienic measures on the part of the food handlers have been reported to introduce contaminant and pathogens that survive and multiply in sufficient numbers to cause illness in the consumer [19,50,73,75]. With regard to AMB, counts above 10^5 have been considered a potential risk for the presence of pathogens [76]. The presence of microorganisms like *E. coli* demonstrates a potential health risk as these organisms are pathogenic and have been implicated in foodborne diseases [77,78]. However, their presence is an indication of possible faecal contamination of food, water or food workers and poor hygienic processing practices [72,79].

The foods being cooked and served by these two kitchens are of unacceptable microbiological quality. The International Commission for Microbiological Specification for Foods [80] states that ready-to-eat foods with plate counts between 0-10^3 is acceptable, between 10^4 to ≤ 10^5 is tolerable and 10^6 and above is unacceptable. *E. coli* and coliform <20 is satisfactory, between 20 to ≤ 10^2 is borderline and > 10^2 is unsatisfactory. The findings that there are significantly higher APC, coliforms and *E. coli* levels from both kitchens were expected, taken into consideration that both kitchens prepare and serve food in violation with the food safety standards. Generally considering the very poor level of good food handling practices particularly personal hygiene, there are likely other factors beyond this study scope, which resulted in the high bacterial levels in the cooked food samples from both kitchens.

Limitations

The research limited itself to the assessment of bacteriological quality of cooked food samples and could not include pathogens like viruses, parasites and other bacteria due to lack of funds.

Conclusion

Based on the results of this study, it is concluded that meals production analysed from these kitchens does not comply with the requirements of good hygienic practices. This study has generally revealed that there is a great need for improving food safety in both women's old and new hostel kitchens at SHUATS Allahabad. The levels of APC, coliforms and *E. coli* counts in all the foods from both kitchens were higher than the food safety standard permissible limits. The findings that majority of the individual respondents did not follow good food handling practices (e.g., smoking, chewing tobacco leaves during food handling, serving food without the use of hand gloves, hair restraints and masks) reveals lack of frequent supervision by the concerned food safety authorities.

From the results obtained in the present study, providing periodic training on personal hygiene and good food handling practices and frequent supervision by the relevant authorities will play a pivotal role in enhancing the safety of foods being prepared and served in these kitchens, as facilities that are frequently inspected had better sanitary condition in comparison to uninspected ones. As better educated food handlers are more likely to practice good hygiene, it is advisable that they should obtain a minimum qualifications of at least secondary school level to be eligible to work as food handlers in university kitchens. Safe food handling practices can be supported by enforcing wearing of clean cloths (or uniforms), hair and mouth coverings and hand gloves while handling food. Foodborne illness can be prevented by good hygiene practices such as the use of Good Manufacturing Practices (GMP) and Hazard Analysis Critical Control Point (HACCP) application in the chain of food production and processing. Education of the food handlers on food safety practices and a close and stringent supervision of ready-to-eat foods prepared and served in these school kitchens should be carried out by relevant authorities to prevent foodborne illness. The results obtained can also create awareness to the management of this university to adopt better control strategies to prevent the foodborne illness outbreaks among students in the school environment in order to ensure and promote food safety. There is a need for further research to investigate the quality of raw materials, raw material storage conditions, cooking temperatures for various foods (as these kitchens did not have any instruments to control or register the temperature during food preparation), cooling time after cooking, display holding temperature and time to discard the food to evidence the actual reasons for these very high bacterial counts in the cooked food samples in order to come up with an overall better idea as to what frequently resulted in foodborne illness outbreaks among the students of this particular university.

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