

*Original Research***Street Vended Foods and Associated Environment in Two Major Cities of India: Microbial Safety Concern****Shagufta Bi, Zunjar Baburao Dubal\*, Kiran Narayan Bhilegaonkar<sup>1</sup>, Anukampa, Sivakumar M., Ravindra Jayavant Zende<sup>2</sup> and Vilas Mahadev Vaidya<sup>3</sup>**

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**Abstract**

Majority of the people in the cities liked to have street food even with the compromising their health. Therefore, the present study was carried out to find out the microbiological profile/safety of street vended foods and associated environmental samples collected from Mumbai and Delhi. A total of 166 samples of foods of animal origin (124) and associated environmental samples (42) were processed for aerobic plate count, enumeration of *Escherichia coli*, *Staphylococcus* spp., sulphite reducing *Clostridia* (SRC) and for detection of *Salmonella* spp. and *Listeria monocytogenes*, while water samples tested for most probable number. Swab samples showed low to marginal APC for Delhi while marginal to high in Mumbai. Notably, *E. coli* and *Staphylococcus* spp. count is higher in table and cloth swabs. Overall, 42.4%, 69.6% and 51.5% swab samples were positive for *E. coli*, *Staphylococcus* spp. and SRC, respectively. APC for raw chicken was  $5.00 \pm 0.17$  &  $5.45 \pm 0.05 \log_{10} \text{cfu g}^{-1}$  for Mumbai and Delhi, respectively while that of  $4.13 \pm 0.18$  and  $4.53 \pm 0.10 \log \text{cfu g}^{-1}$  for raw egg and raw milk from Delhi and  $4.00 \log \text{cfu g}^{-1}$  for raw egg from Mumbai. Salad and chutney samples showed marginal to high APC ( $3.5$  to  $4.7 \log \text{cfu g}^{-1}$ ) with the presence of *E. coli* and *Staphylococcus* spp. in majority of the samples in both the cities. Overall, 38.75, 51.25 and 35.0% raw foods; 52.0, 36.0 and 8.0% milk products and 22.72, 31.81 and 13.63% cooked food samples were positive for *E. coli*, *Staphylococcus* spp. and SRC, respectively. *Salmonella* spp. was present in only one chutney sample while *L. monocytogenes* was absent in all. Cooked chicken from Mumbai had  $1.89 \pm 0.56 \log \text{cfu g}^{-1}$  with mean *E. coli* and *Staphylococcal* count is  $<1.6 \log \text{cfu g}^{-1}$ . Boiled egg, omelette and boiled milk also had limited microbial load (APC) with majority of the samples free from *E. coli*, *Staphylococcus* spp. and SRC. Only 2/9 water samples have high MPN count. Of the 80 *Staphylococcus* spp. isolates, 23 (28.75%) were found to be positive for *nuc* and *coa* genes in PCR indicated as *S. aureus* with an overall presence of 14.64%. Though the microbiological quality of all cooked products was found good except for



one sample, proper sanitation, hygienic environment, good hygienic raw food, clean water supply and personnel sanitation should be adopted while doing the street vending operations.

**Key words:** Street Food, *E. coli*, *L. monocytogenes*, *Salmonella*, *Staphylococcus*, SRC

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## Introduction

Street-vended foods are defined as foods and beverages prepared and/or sold by vendors in streets and other public places for immediate consumption or consumption at a later time without further processing or preparation (WHO, 1996). Worldwide, about 2.5 billion people consume street foods every day. The picture of street food market is different depending on country as in developing countries a large proportion of ready to eat foods (RTE) are sold mainly on the streets (Faruque *et al.*, 2010). Information about numbers of vendors in different cities in India is lacking. The street food vendors are found on the roadsides, near schools, bus stations, railway stations, hospitals and offices where toilets and garbages may also be found in the vicinity leading to contamination of foods. However, food handlers including food vendors are the major contaminants of food because of poor hygienic conditions, dirty clothes and also if they are suffering from any infectious disease. Thus, food handling personnel are key in ensuring food safety throughout the food production chain and during storage as street foods can easily be contaminated by dust and insects from nearby garbage, hands of intending buyers and rains whenever foods are not protected properly (WHO, 2013). Contamination of foods sold by street vendors can also be contributed by washing and processing water (Khalil *et al.*, 1994). Thus, street food acts as one of the major sources of foodborne illness. Health hazards due to street foods may also be because of poor education, poor hygiene and lacking in training skills. Generally, these health implications are due to lack of running water, hand and dish washing usually done in plastic containers and sometimes without soaps/sanitizers (Kwiri *et al.*, 2014). Using raw materials (meat, eggs or fishes) which might be contaminated with faeces (manure, both of human and animal origin) or water (used during irrigation and cleaning) increases the health risk potential (Beuchat, 2002; Johannessen *et al.*, 2002). The global incidence of foodborne disease is difficult to estimate, but it has been reported that in 2005 alone 1.8 million people died from diarrheal diseases. A great proportion of these cases can be attributed to contamination of food and drinking water. Potential health risks are associated with contamination of food by *E. coli*, *Salmonella* Typhimurium, *Staphylococcus aureus* and other pathogenic organisms especially during processing and post cooking handling. Commonly detected food borne bacterial pathogens include *E. coli*, *Bacillus cereus*, *Clostridium perfringens*, *Staphylococcus aureus* and *Salmonella* spp. People depending on street food have been reported to suffer



from food borne diseases like cholera and typhoid fever (Kaul & Agarwal, 1988; Rodrigue *et al.*, 1990; Todd, 1992). The data regarding foodborne pathogens in foods of animal origin and their illnesses in human is lacking particularly from Mumbai and Delhi where thousands of vendors are operating and serving foods to lakhs of people every day. Therefore, the present study was conducted to evaluate the bacterial profiling of the street vended foods of animal origin and its associated environmental samples collected from Delhi and Mumbai cities.

## Materials and Methods

### Sample Collection

A cross-sectional study was carried out from September, 2014 to April, 2016, in which **a total of 166 samples comprising foods of animal origin (124) and associated environmental samples (42 including 9 water samples)** from different roadside food vendors located in Delhi and Bareilly cities **were collected by adopting all aseptic precautions. In this study**, samples depending on the availability of food articles with the vendors were collected randomly only once from one vendor each from different localities of Delhi namely, New Delhi, Old Delhi, Hazarat Nizamuddin and Anand Vihar and Byculla station, Kalachauki, Parel and Sewri localities in Mumbai. Approximately, 50-100 gm food samples was collected in sterile Nasco sampling bags while swab samples were collected in screw capped tube or test tube containing sterilized 10 ml maintenance media (0.85% NSS + 0.1% peptone) (Morris & Wells, 1970). For water samples, sterilized multipurpose sample collector (Hi Media) were used for collection of 100-150 ml water sample. Each sample was collected in sterile polythene bag or glass/plastic container and then transported in cold condition in cooler immediately to the Division of Veterinary Public Health, ICAR-IVRI, Bareilly (for Delhi), and Department of Veterinary Public Health, Bombay Veterinary College, Parel (for Mumbai). Samples were processed for microbiological analysis immediately after reaching to respective labs.

### Aerobic Mesophilic Plate Count (APC)

Aerobic mesophilic plate count (APC) of all the samples was done following the procedure described in manual for microbial methods (FSSAI, 2012). Briefly, 10 g of solid sample (raw foods, cooked foods and sweets) was weighed and aseptically taken into sterile polythene bag containing 90 ml of 0.1% peptone or 25 g of sample in 225 ml of 0.1% peptone. It was homogenized in the stomacher (Seward lab, UK) for 1 min. Ten fold serial dilutions of all the food samples were then prepared in 0.1% peptone water up to  $10^{-4}$  or  $10^{-5}$  dilutions. In case of swabs, test tube containing swabs were shaken on vortex for 30 sec for uniform distribution of microorganisms and then ten-fold serial dilutions were made as described earlier. An inoculum of 0.1 ml from each  $10^{-3}$ ,  $10^{-4}$  and  $10^{-5}$  dilution (or required dilution) was poured in duplicate sterile pre-label petri plates and molten autoclaved nutrient agar was poured and incubated at 37°C for 24-

48 hours. The number of colonies seen were counted using a colony counter, recorded and calculated as colony forming unit per gram (cfu/g) (FSSAI, 2012).

### **Enumeration of *E. coli*, *Staphylococcus* spp. and SRC and Screening for Presence of *Salmonella* spp. and *L. monocytogenes***

#### ***Escherichia coli***

Enumeration and isolation of *E. coli* was done using spread plate technique (BIS, 1976). For this, 0.1 ml inoculum of  $10^{-1}$  and  $10^{-2}$  dilutions was spread on the pre-prepared Eosin methylene blue agar plates using a sterile spreader. The plates were incubated at 37°C for 24-48 hours and the plates having 30-300 colonies showing typical morphological characteristics (black or purple colonies with green metallic sheen) were counted. Selected suspected colonies for each sample were further isolated on fresh EMB plates incubated at 37°C for 24 hours and further confirmed by gram staining and biochemical tests (Indole, MR-VP and Citrate test). The number of viable colonies of *E. coli* per g of sample was determined by multiplying by the dilution factor(s) and dividing by the mass of the sample.

#### ***Staphylococcus aureus***

The enumeration and isolation of *Staphylococcus* spp. was done using surface plating method (FSSAI, 2012). For this, 1 ml inoculum of  $10^{-2}$  dilution (from above prepared dilutions) was spread on the pre-prepared Vogel Johnson agar or Baird Parker agar plates in triplicate (0.4, 0.3 and 0.3 ml inoculums) using a sterile spreader (Hi Media, India). Allow the plates to completely absorb the inoculums by keeping the plates in upright position in incubator. The inverted plates were then incubated at 37°C for 48 hours. All the three plates showing typical morphological characteristics (circular, smooth, convex, moist 2-3 mm grey black to jet black colonies with yellowish or opaque zone) were counted and noted. Total numbers of colonies were multiplied with the reciprocal of the dilution used and reported as *Staphylococcus* spp. per g or ml. Suspected isolates then subjected to polymerase chain reaction (PCR) for confirmation of *S. aureus* by amplifying *coa* and *nuc* genes (Brakstad *et al.*, 1992; Hookey *et al.*, 1998).

#### **Sulphite Reducing Clostridia (SRC)**

Enumeration and isolation of sulphite reducing *Clostridia* was done by overlay method (Vaidya *et al.*, 2010). Sodium polymixin sulphadiazine agar (SPS) was used for enumeration of sulphide reducing clostridia (Angelotti *et al.*, 1962). For this, 1 ml inoculum from  $10^1$  and/or  $10^2$  dilution of each sample was taken into the sterile test tube to which molten (42°C-45°C) SPS agar was poured (Vaidya *et al.*, 2005). Inoculum was mixed, allowed to cool and sealed by pouring the layer of liquid paraffin to create an anerobic condition. The tubes were incubated at 44°C for 24-48 h. The black coloured colonies with a cottony growth

were counted. Total numbers of colonies were multiplied with the reciprocal of the dilution used and reported as SRC per g or ml.

### ***Salmonella* spp.**

Screening of foods of animal origin and associated samples for *Salmonella* spp. was done according to FSSAI, 2012. Briefly, 25 g of food sample was mixed with 225 ml buffered peptone water and incubated at 35°C to 37°C for 24 h. For swab samples, only 10 ml initial inoculum from maintenance medium was taken in 90 ml medium. One ml of enriched broth culture was then transferred to 10 ml Selenite Cysteine broth and 1 ml to tetrathionate broth. The tubes were incubated at 35°C for 24 h. A loopful of inoculum from these cultures was then streaked on Hektoen Enteric agar (HEA) plates and incubated all the plates at 35°C for 24-48 h. The bluish green colonies with or without black centres were picked up and streaked on fresh HEA plates, incubated at 35°C for 24 h. Morphologically suspected colonies then inoculated in Triple Sugar Iron (TSI) agar and Lysine Iron Agar (LIA) slants with standard procedure and incubated at 35°C for 24-48 h. Typical reaction of alkaline (red) slant, acid (yellow) butt with or without H<sub>2</sub>S production (blackening in butt) in TSI, and of alkaline (purple) slant, alkaline (purple) butt with H<sub>2</sub>S production (blackening in butt) in LIA was considered as presumptive positive for *Salmonella*. These cultures were further tested by gram staining, biochemical tests (Indole, MR, VP and Urease test) and PCR assay targeting *invA* gene (Rahn *et al.*, 1992). Results were expressed as *Salmonella* present per 25 g.

### ***Listeria monocytogenes***

Samples were screened for isolation and identification of *Listeria monocytogenes* with slight modification (FSSAI, 2012; Becker *et al.*, 2006). Briefly, 25 g of food sample was mixed with 225 ml Frazer broth and incubated at 30°C for 24 h. For swab samples, only 10 ml initial inoculum from maintenance medium was taken in 90 ml medium. One ml inoculum from each broth showing turbidity were transferred to 9 ml Frazer broth and incubated at 35°C to 37°C for 48 hours. From each broth tube showing turbidity, a loopful of inoculum was streaked on PALCAM agar plates and incubated at 37°C for 24 hours. Plates were examined for listerial growth and colony characteristics as greyish green or olive green with black centre surrounded by black halo.

Representative isolates of suspected *Escherichia coli*, *Staphylococcus aureus*, Sulphite reducing *Clostridia* (SRC), *Salmonella* spp. and *Listeria monocytogenes* were subjected to gram staining and biochemical tests or PCR for their confirmation.

### **Water Sample Analysis for Coliform**

Water samples were analysed by Most Probable Number (MPN) method using 5 tubes technique of FSSAI (2012). For this, 3 sets each of 5 tubes of Mac Conkey's broth were prepared in such a way that 1<sup>st</sup> set

contained double strength MacConkey's broth (10 ml in each tube), 2<sup>nd</sup> and 3<sup>rd</sup> sets contained single strength Mac Conkey's broth (10 ml in each tube) with inverted Durham's tube in each tube. All the tubes were properly autoclaved before using for the tests. Each water sample was vigorously shaken before inoculating the broths. Ten ml water sample was inoculated in each tube of 1<sup>st</sup> set while 1 ml and 0.1 ml water sample was inoculated in each tube of 2<sup>nd</sup> and 3<sup>rd</sup> set (single strength), respectively. All the inoculated tubes were incubated at 37°C for 24-48 hours. The number of tubes showing acid and gas production was noted. The MPN index per 100 ml water sample was determined and expressed as coliform count = X MPN/100 ml (FSSAI, 2012).

### Statistical Analysis

The data were subjected to statistical analysis following the procedure described by Rangaswamy (1995). The basic statistical parameters (mean, median, standard deviation, coefficient of variation, maximum and minimum values) and correlation procedure of log values of different micro-organisms were calculated.

### Results

Results of environmental and food samples are presented in Table 1-3.

**Table 1:** Microbiological profile of the street vended foods and associated environmental samples collected from Delhi

Type of sample	Meat Vendors				Egg vendors				Milk vendors			
	APC	<i>E. coli</i>	<i>Staph. spp.</i>	SRC	APC	<i>E. coli</i>	<i>Staph. spp.</i>	SRC	APC	<i>E. coli</i>	<i>Staph. spp.</i>	SRC
HS	2.48*	1.69*	1.69*	Nil	1.38 ± 0.22	Nil	Nil	1.15 ± 0.15	ND	ND	ND	ND
TS	2.54*	1.85*	1.84*	1.47*	ND	ND	ND	ND	ND	ND	ND	ND
PS	2.47*	Nil	Nil	Nil	ND	ND	ND	ND	4.73*	Nil	2.27*	Nil
Raw chicken	5.45 ± 0.05	3.02 ± 0.11	2.70 ± 0.06	2.41 ± 0.16	ND	ND	ND	ND	ND	ND	ND	ND
Chicken gravy	1.47*	Nil	Nil	Nil	ND	ND	ND	ND	ND	ND	ND	ND
Cooked fish	1.97*	Nil	Nil	Nil	ND	ND	ND	ND	ND	ND	ND	ND
Salad	4.41 ± 0.07	2.39*	2.39*	Nil	4.43 ± 0.11	Nil	2.06 ± 0.29	1.20 ± 0.09	ND	ND	ND	ND
Chutney	3.51*	Nil	Nil	1.6*	3.95 ± 0.10	1.3*	1.50 ± 0.27	2.69*	ND	ND	ND	ND
Raw egg	ND	ND	ND	ND	4.13 ± 0.18	2.02 ± 0.20	1.70 ± 0.07	2.0 ± 0.05	ND	ND	ND	ND
Boiled egg	ND	ND	ND	ND	3.02 ± 0.46	1.47*	1.47*	1.77 ± 0.7	ND	ND	ND	ND
Omelette	ND	ND	ND	ND	2.44 ± 0.25	Nil	Nil	Nil	ND	ND	ND	ND
Raw milk	ND	ND	ND	ND	ND	ND	ND	ND	4.53 ± 0.10	2.87*	2.04 ± 0.09	1.0*
Boiled milk	ND	ND	ND	ND	ND	ND	ND	ND	3.23 ± 0.50	1.0*	2.41 ± 0.09	1.0*
Paneer	ND	ND	ND	ND	ND	ND	ND	ND	4.43 ± 0.12	2.17 ± 0.10	1.74 ± 0.11	1.30*
Pedha	ND	ND	ND	ND	ND	ND	ND	ND	4.41 ± 0.31	Nil	Nil	Nil
Lassi	ND	ND	ND	ND	ND	ND	ND	ND	4.65 ± 0.08	Nil	1.9*	Nil
Curd	ND	ND	ND	ND	ND	ND	ND	ND	4.60 ± 0.05	2.26 ± 0.30	1.89 ± 0.08	Nil
Rasgulla	ND	ND	ND	ND	ND	ND	ND	ND	4.30 ± 0.27	1.77*	2.07*	Nil

\*only single observation/sample, HS- hand swab, TS- table swab, PS- plate swab, SRC-sulphide reducing clostridia

**Table 2:** Microbiological profile of the street vended foods and associated environmental samples collected from Mumbai

Type of sample	Meat Vendors				Egg vendors				Fish vendor			
	APC	<i>E. coli</i>	<i>Staph. spp.</i>	SRC	APC	<i>E. coli</i>	<i>Staph. spp.</i>	SRC	APC	<i>E. coli</i>	<i>Staph. spp.</i>	SRC
HS	4.52 ± 0.45	2.69 ± 0.21	3.09 ± 0.12	2.49 ± 0.13	4.46*	Nil	Nil	Nil	ND	ND	ND	ND
TS	5.42 ± 0.85	3.19 ± 0.15	2.91 ± 0.38	2.70*	4.76*	Nil	Nil	2.70*	ND	ND	ND	ND
CS	4.66 ± 0.96	3.80 ± 0.37	3.59 ± 0.43	2.60 ± 0.10	4.65*	Nil	Nil	2.70*	ND	ND	ND	ND
PS	4.49 ± 0.30	3.33 ± 0.08	3.07 ± 0.21	2.70*	ND	ND	ND	ND	ND	ND	ND	ND
Raw chicken	5.00 ± 0.17	3.67 ± 0.05	3.12 ± 0.47	2.33 ± 0.38	ND	ND	ND	ND	ND	ND	ND	ND
Cooked Chicken	1.89 ± 0.56	1.60 ± 0.50	1.50 ± 0.25	Nil	ND	ND	ND	ND	ND	ND	ND	ND
Cooked fish	ND	ND	ND	ND	ND	ND	ND	ND	2.95*	1.0*	Nil	1.3*
Salad	4.44 ± 0.61	2.83 ± 0.53	2.86 ± 0.33	2.7*	4.95*	2.9*	Nil	Nil	3.49*	2.7*	2.6*	Nil
Chutney	4.57 ± 0.81	2.00 ± 1.00	2.66 ± 0.66	Nil	4.26 ± 0.41	2.89 ± 0.11	3.21 ± 0.13	2.70*	3.85*	3.34*	3.23*	Nil
Raw egg	ND	ND	ND	ND	4.00*	Nil	2.00*	Nil	ND	ND	ND	ND
Boiled egg	ND	ND	ND	ND	1.00*	Nil	2.00*	Nil	ND	ND	ND	ND
Omelette	ND	ND	ND	ND	2.30 ± 1.30	Nil	Nil	Nil	ND	ND	ND	ND

\*only single observation/sample, HS- hand swab, TS- table swab, CS, Cloth swab, PS- plate swab, SRC-sulphide reducing clostridia

**Table 3:** Number of samples positive for *E. coli*, *Staphylococcus* spp. and SRC

Type of Samples	No. of Samples		<i>E. coli</i>		<i>Staphylococcus</i> spp.		SRC	
	Mumbai	Delhi	Mumbai	Delhi	Mumbai	Delhi	Mumbai	Delhi
HS	4	5	2	1	4	1	3	2
TS	6	1	2	1	4	1	2	1
CS	7	0	4	0	6	0	6	0
PS	7	3	4	0	6	1	3	0
Raw chicken	4	14	2	14	3	5	2	12
Cooked chicken	6	1	2	0	3	0	0	0
Cooked fish	1	1	1	0	1	0	0	0
Salad	7	14	4	1	5	6	1	7
Chutney	7	7	5	1	5	2	1	2
Raw egg	1	17	0	3	1	7	0	2
Boiled egg	2	4	0	1	0	1	0	2
Omelette	1	3	0	0	0	0	0	0
Raw milk	0	9	0	1	0	7	0	1
Boiled milk	0	3	0	1	0	2	0	1
Paneer	0	12	0	10	0	5	0	1
Pedha	0	2	0	0	0	0	0	0
Lassi	0	2	0	0	0	1	0	0
Curd	0	4	0	2	0	2	0	0
Rasgulla	0	2	0	1	0	1	0	0
Total	53	104	26 (49.05%)	37 (36.53%)	38 (71.69%)	42 (40.38%)	18 (33.96%)	31 (29.80%)

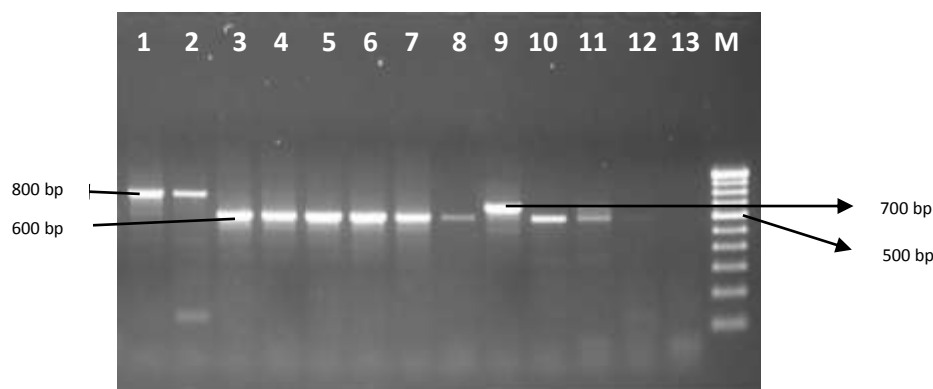
HS- Hand swab, TS- Table swab, CS, Cloth swab, PS- Plate swab

Swab samples collected from Delhi showed low to marginal APC while marginal to high microbial load in Mumbai with highest in table swab samples ( $5.42 \pm 0.85$  cfu  $g^{-1}$ ) and lowest in plate swabs ( $4.49 \pm 0.30$  cfu  $g^{-1}$ ). Notably, the *E. coli* and *Staphylococcus* spp. count is higher in table and cloth swabs. Overall, 42.4%, 69.6% and 51.5% swab samples were positive for *E. coli*, *Staphylococcus* spp. and SRC, respectively. Maximum contamination occurred in table and cloth swab samples as compared to hand and plate swab samples. Water samples from Mumbai tested for MPN showed 7 samples were within the acceptable limit while two had higher MPN count i.e. 17 and 1600/100 ml. Analysis of food samples in the present study

also revealed variable results with higher microbial load in raw and uncooked foods (salad, chutney) where APC for raw chicken was  $5.00 \pm 0.17$  &  $5.45 \pm 0.05$   $\log_{10}\text{cfu g}^{-1}$  for Mumbai and Delhi, respectively. APC of  $4.13 \pm 0.18$  and  $4.53 \pm 0.10$   $\log \text{cfu g}^{-1}$  was observed for raw egg and raw milk in Delhi and  $4.00$   $\log \text{cfu g}^{-1}$  for raw egg in Mumbai. Semi cooked foods and raw foods like salad and chutney are more vulnerable to microbial contamination. In the present investigation also, salad and chutney samples showed marginal to high APC, within the range of 3.5 to 4.7  $\log \text{cfu g}^{-1}$  with the presence of *E. coli* and *Staphylococcus* spp. in majority of the samples in both the cities. One sample (chutney) was found to be positive for *Salmonella* spp. while *L. monocytogenes* was absent in all the samples. Overall 38.75, 51.25 and 35% raw food sample in this study were positive for *E. coli*, *Staphylococcus* spp. and SRC respectively.

In contrast to the finding of raw foods, majority of the cooked foods were found to be safe where cooked chicken (chicken 65, tandoor chicken, chicken gravy) from Mumbai had  $1.89 \pm 0.56$   $\log \text{cfu g}^{-1}$  with mean *E. coli* and Staphylococcal count is  $<1.6$   $\log \text{cfu g}^{-1}$ . Boiled egg, omelette and boiled milk also had limited microbial load (APC) with majority of the samples free from *E. coli*, *Staphylococcus* spp. and SRC. Though the microbial load was low, overall, 22.72, 31.81 and 13.63% cooked food samples were positive for *E. coli*, *Staphylococcus* spp. and SRC, respectively. Milk products collected from Delhi showed APC count in the range of  $4.30 \pm 0.27$  to  $4.65 \pm 0.08$   $\log \text{cfu g}^{-1}$  where *E. coli*, *Staphylococcus* spp. and SRC was found to be nil to minimum in many of the samples. However, paneer samples have little high APC including the pathogens (Table 1). In case of milk products, 52.0, 36.0 and 8.0% samples were positive for *E. coli*, *Staphylococcus* spp. and SRC, respectively.

Of the 80 *Staphylococcus* isolates 23 (28.75%) were found to be positive for *nuc* and *coa* genes (Fig. 1) in PCR which were confirmed as *S. aureus* with an overall presence of 14.64% in all the samples tested in the present study.



**Fig. 1:** Agarose gel of PCR amplified Coa gene of *S. aureus* isolates  
Lane M : 100 bp DNA ladder; Lanes 1 -12 : Positive samples (*coa* gene);  
Lane 13 : Negative control without bacterial DNA

## Discussion

Quality and safety of street vended foods are generally depending on the level of contamination due to various microorganisms encountered due to unhygienic practices, poor quality water, poor infrastructure and poor personal hygiene. In our study, swab samples showed low to marginal APC, *E. coli* and *Staphylococcus* spp. count with highest in table and cloth swab samples. Swab samples showed marginal to high microbial load in Mumbai as compared to Delhi which may be indicated that the cleaning and sanitation of dishes, cloths and tables were not adequate. Overall, 42.4%, 69.6% and 51.5% swab samples were positive for *E. coli*, *Staphylococcus* spp. and SRC, respectively. In comparison to the present findings, the mean bacterial colony count of hand swab samples observed by Okareh and Erhahon (2015) was  $3.07 \times 10^5$  ( $5.48 \log_{10} \text{cfu/ml}$ ) with the maximum of  $4.16 \times 10^5$  and minimum of  $2.09 \times 10^5$  where 38.3% and 16.7% samples were found positive for *S. aureus* and *E. coli*, respectively. Similarly, Vaidya *et al.* (2010) also observed that, enterococci and faecal coliforms (30.43%) showed higher prevalence than the *P. aeruginosa* (21.01%), *E. coli* (18.00%), *Clostridium* spp. (16.67%), *S. aureus* (13.04%) and *B. cereus* (5.80%) in swab samples. They also observed the average clostridial count of  $2.73 \pm 0.17 \log \text{cfu/cm}^2 \pm \text{S.E.}$  with the prevalence of 13.88% in swab samples from various carcass sites (Vaidya *et al.*, 2005). On the other hand, wooden scraping samples tested for *E. coli* revealed 16.67% positivity (Panda *et al.*, 2012). Maximum contamination due to pathogenic and spoilage-causing organisms observed on the floors (slaughterhouse, evisceration room and processing plant) while minimum in water and hand swab samples (Vaidya *et al.*, 2010). In the present study also, maximum contamination occurred in table and cloth swab samples as compared to hand and plate swab samples.

Generally, raw foods of animal origin get contaminated with various pathogenic and spoilage organisms during slaughtering and processing operations. Analysis of food samples in the present study also revealed variable results with higher microbial load in raw and uncooked foods (salad, chutney) where APC for raw chicken was  $5.00 \pm 0.17$  &  $5.45 \pm 0.05 \log_{10} \text{cfu g}^{-1}$  for Mumbai and Delhi, respectively. Variable mean bacterial count of raw chicken was also observed by various workers where it was ranged from  $51-55 \times 10^4$  to  $4.0-250 \times 10^4 \text{ cfu/g}$  (Sengupta *et al.*, 2011) and  $10^3$  to  $10^6 \text{ cfu/g}$  (Huang *et al.*, 2014). Sengupta *et al.* (2011) also noted *E. coli* and staphylococcal count in raw chicken meat. Varied prevalence rate i.e. 2-68% of *E. coli* in chicken meat has also been reported by many workers (Gupta & Gupta, 2009; Cohen *et al.*, 2009; Iroha *et al.*, 2011; Adeyanju and Ishola, 2014). *C. perfringens* was isolated from 60-94% chicken samples (Guran and Oksuztepe, 2013).

In present study, APC of  $4.13 \pm 0.18$  and  $4.53 \pm 0.10 \log \text{cfu g}^{-1}$  was observed for raw egg and raw milk in Delhi and  $4.00 \log \text{cfu g}^{-1}$  for raw egg in Mumbai while Chaemsanit *et al.* (2015) recorded maximum microbial load in egg shell (2.9 to 6.2 log CFU/mL) followed by egg content (3.0 log CFU/mL) with the presence of *Salmonella* spp. in 2 samples and pathogenic bacteria in 50% samples. In another study, Dhanze

*et al.* found TVC within the range of 4.85 to 5.653 log<sub>10</sub>cfu/shell (Dhanze *et al.*, 2012). The earlier studies have also reported a total bacterial count (TBC) of 13 × 10<sup>6</sup> cfu/ml in raw milk (Shojaei & Yadollahi, 2008) and considerably high SPC in vendor's milk as compared to the pasteurized milk samples (Agarwal *et al.*, 2012). The study carried out in Guwahati reported the contamination of *Staphylococcus aureus* in all the milk samples (*n* =20) tested, with a mean bacterial count of 4.60 × 10<sup>4</sup> per ml while *E. coli* was present in 12 samples with a mean bacterial count of 4.12 × 10<sup>4</sup> per ml (Baruah *et al.*, 2008). In a similar study from Malaysia, 930 raw milk samples were tested where ~90% samples were contaminated with coliforms, 65% with *E. coli*, and 61% with *Staphylococcus aureus* (Chye *et al.*, 2004).

In the present investigation, salad and chutney samples showed marginal to high APC, within the range of 3.5 to 4.7 log cfu g<sup>-1</sup> with the presence of *E. coli* and *Staphylococcus* spp. in majority of the samples in both the cities. Total aerobic bacterial count of salad, chutney and masala were reported by various workers, where Hannan *et al.* recorded mean bacterial count for salad was ranged from 1.0 × 10<sup>3</sup> to 5.8 × 10<sup>8</sup> cfu/g (Hannan *et al.*, 2014); Osamwonyi *et al.* (2013) recorded 1.46 × 10<sup>4</sup> to 2.84 × 10<sup>4</sup> log<sub>10</sub>cfu/g (salad), Ganguli *et al.* (2004) recorded 5.0 to 6.3 log<sub>10</sub> cfu/g (green chutney), Ghosh *et al.* (2004) recorded 6.5 log<sub>10</sub> cfu/g (green chutney) and Kudo *et al.* (2006) recorded >5.39 log<sub>10</sub>cfu/g (turmeric, garam masala, curry powder and paprika). Salad and chutney seems to be highly contaminated due to frequent handling practices, small pieces, contaminated water used for washing and preparation, and served as uncooked food products. Therefore, many pathogenic organisms have been isolated by many workers from these samples. In one study, staphylococcal count of 6.0 ± 0.4 log cfu/g and coliform count of 4.9 ± 0.3 log cfu/g in green chutney samples was observed by Ganguli *et al.* where 68% staphylococcal strains were confirmed as *S. aureus* (Ganguli *et al.*, 2004). Similarly, Ghosh *et al.* also noted the staphylococcal count of 7.5 cfu/g in green chutney samples collected from street vendors from Patiala (Ghosh *et al.*, 2004). About 66.66% of salad samples were infected with *Enterococcus*, 69% had *E. coli* contamination and 83.33% of samples were contaminated with yeast while negative for presence of *Salmonella* and mould (Avazpour *et al.*, 2013). In present study, one sample (chutney) was found to be positive for *Salmonella* spp while *L. monocytogenes* was absent in all the samples. In the similar line, *C. difficile* spores were detected in 3 (7.5%) of the 40 salad samples (Bakri *et al.*, 2009) and different samples (2.9%) consisting of two ready-to-eat salads and one heart of lettuce and one lamb's lettuce salad (Eckert *et al.*, 2013).

Majority of the cooked food samples tested in this study revealed low microbial count (TVC) and free from *E. coli*, *Staphylococcus* spp. and SRC indicated safe for consumption. Overall, 22.72, 31.81 and 13.63% cooked food samples were positive for *E. coli*, *Staphylococcus* spp. and SRC, respectively. Kwiri *et al.* also revealed TAC and TCC ranging from 8-175 × 10<sup>2</sup> and 8-85 × 10<sup>2</sup> for ready to eat food stuff comprising of chicken and beef stew, egg rolls, doughnuts and boiled mealie cobs (Kwiri *et al.*, 2014). Sofi *et al.* (2013) also reported the TVC for chicken gravy in the range of 2.42 ± 0.12 to 2.80 ± 0.12 log<sub>10</sub> cfu/g where all the

samples were found negative for *E. coli*. Similarly, Selvan *et al.* (2007) also reported the TVC, coliform and staphylococcal counts of chicken products (chicken kebab, chicken keema, chicken sausages and chicken nuggets) collected in Chennai were  $4.52 \pm 0.12$ ,  $1.13 \pm 0.46$  and  $4.88 \pm 0.21 \log_{10}$  cfu/g. In case of omelette, 20% samples were found positive for *E. coli* and *Salmonella* spp. by Krishnamoorthy and Paul (2004) whereas Joseph *et al.* (1999) observed heavily contaminated ( $62-68 \times 10^4$  and  $65-70 \times 10^4$ ) hard boiled eggs obtained from Lagos and Oyo. Twenty three isolates (28.75%) were confirmed as *S. aureus* with an overall presence of 14.64% in the present study. In contrast, 85% (17/20) isolates were approved as *S. aureus* by El-Hadedy and El-Nour (2012) while Okareh and Erhahon (2015) found that, 30% and 25% food samples were positive for *S. aureus* and *B. cereus*, respectively.

Milk products collected from Delhi showed APC count from 4.30 to 4.65 log cfu g<sup>-1</sup> where *E. coli*, *Staphylococcus* spp. and SRC was found to be nil to minimum in many of the samples. However, paneer samples have little high APC. Karthikeyan and Pandiyan (2013) noted the total viable count of khoa based milk sweets obtained from local vendors, private manufacturers and organized dairies ranged from  $1.2 \times 10^5$  to  $8 \times 10^5$ ,  $1.9 \times 10^3$  to  $2.3 \times 10^5$  and  $8 \times 10^2$  to  $3.1 \times 10^4$ , respectively.

Hey also observed the prevalence of *E. coli* (14.13%) and *S. aureus* (17.39%) in these milk products. In another study, the total bacterial load for pedha was observed as  $1.5 \times 10^3$  to  $6.0 \times 10^7$  per gm with very high *S. aureus* and coliform counts (Bandeekar *et al.*, 1998). On the other hand, Kumar and Prasad revealed that, out of 135 samples, 25 samples were found contaminated with *Staphylococcus* (14) and *E. coli* (11), and highest contamination was recorded in burfi (33.3%) followed by dahi (20%), gulab jamun (20%), butter (20%), khoa (13.3%) and ice-cream (6.6%), suggesting that it could be due to contaminated environment and unhygienic handling or preparation (Kumar & Prasad, 2010). Overall, 38.75, 51.25 and 35.0% raw food samples in this study were positive for *E. coli*, *Staphylococcus* spp. and SRC, respectively. In case of milk products, 52.0, 36.0 and 8.0% samples were positive for *E. coli*, *Staphylococcus* spp. and SRC, respectively. *Salmonella* spp. was present in chutney sample while *L. monocytogenes* was absent in all the raw food samples.

## Conclusion

It is concluded from the present findings that, raw foods and swab samples are moderate to highly contaminated by microorganisms. Further, the level of microbial contamination is varied from vendor to vendor. Though pathogenic microbial load is less in many of the food samples (except few salad and chutney samples where it was higher), regular monitoring is required. Interestingly, the microbiological quality of all the cooked products of the present study was found to be good except for one cooked sample. Therefore, in order to prevent contamination of meat, egg and milk and their products, proper sanitation,

hygienic environment, good hygienic feed and water supply and personnel sanitation should be adopted while doing the street vending operations.

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