Influence of The Hygienic Status of Food Contact Surfaces and Handler's Hands on The Microbial Safety of Ready to Eat Foods

Karima Mogahed Fahim*, Lamiaa Ibrahim Ahmed and Ayah Badawi Abdel-Salam

Department of Food Hygiene and Control, Faculty of Veterinary Medicine, Cairo University, Giza 12211, Egypt
*Corresponding author: dr.karima_fhc@cu.edu.eg

ABSTRACT

Ready-to-eat foods "RTEs" remain a public health issue that needs to be addressed to protect consumers' health. The study assessed the hygiene of food contact surfaces, including the food handler's hands and their impact on the microbial safety of the produced RTEs. A total of 150 samples of food contact surfaces swabs (64), food handler's hand swabs (41), and RTE foods (45) were collected from four restaurants in Cairo governorate, Egypt, and microbiologically examined. Food contact surfaces swabs showed significantly high aerobic mesophilic microorganisms and coliform levels with mean counts of ($7.32 \pm 6.99 \log^{10}$ cfu and 6.89 ± 6.58 MPN/cm^2, respectively $P<0.05$). The examined hand swabs showed a high incidence of total Staphylococci and S. aureus (7.18 ± 6.15 and $6.15 \pm 6.15 \log^{10}$ cfu/cm^2, respectively). The examined swabs and RTEs were contaminated with yeast and mold with non-significant differences ($P>0.05$). Food-borne pathogens, S. aureus, and *E. coli* were isolated in percentages of (31.25 and 9.38%) from hand swabs, (19.51 and 12.19%) from surface swabs, and (0.0 and 22.22%) from RTEs samples. Remarkably, Salmonella was detected in only one sample (2.20%) of cheese-based products and one sample of hand swabs (1.56%), which suggests cross-contamination. Our findings reveal a strong positive correlation between surface contamination and the contamination level of RTE foods, which proves that food contact surfaces and handler's hands are the main ways of pathogens transmission to RTE foods. Therefore, the training of food handlers needs to be prioritized, applying for effective sanitation programs, GMPs and HACCP.

Key words: Cross contamination, Contact surfaces, Food safety, *S. aureus, E. coli,* Salmonella

INTRODUCTION

Foods that are ready-to-eat (RTEs) are available for direct consumption at the sale point without further processing. They can be raw or cooked, in a hot or cold state and without further heat treatment and they commonly defined by various terms include; instant, ready, convenient and fast foods. As easy to produce, readily available and tasty, RTEs are commonly eaten as choice meals (Makinde et al. 2020). WHO approximated more than 200 diseases can be attributed to food (FAO/WHO 2003), food borne illness increases due to massive commercial food production and growing consumer preferences for ready-to-eat meals (RTE), (Christison et al. 2008); over 35% of the population consumed above 25% of their daily energy consumption outside the home (Lachat et al. 2010).

In low- and middle-income countries, it is reported that many RTEs vendors are of low education, consequently they unaware of proper food handling and hygienic practices. RTEs are usually sold outdoors, thereby exposing them to several microorganisms. Thus, improperly prepared and contaminated RTEs may cause foodborne illnesses can range from mild to frequent nausea, vomiting and diarrhea to serious complications as cancers and even death (Kamala et al. 2018; Makinde et al. 2020).

Food contamination can be occurred by various reasons including; contaminated ingredients, uncleaned food contact materials, improper personal hygienic practices of food handlers, improper storage temperatures, inadequate cooking and cross-contamination; in addition to a lack or defective food safety management system (Ahmed et al. 2015; Othman 2015). Contamination of food contact surfaces serves as one of the most frequent reasons for food borne diseases worldwide, moreover, many pathogenic microorganisms are spread by contaminated hands, which usually harbor normal microbial flora as well as transient microbes from the environment; 97% of foodborne illnesses associated with food service operations are caused by food handlers' malpractices (Lahou et al. 2012; Oranusi et al. 2013). Furthermore, the insufficient

cooking, cross-contamination and storage condition are accountable for (60–78%) of the food borne disease burden (Augustin et al. 2020).

There are many different types of raw materials used in food service operations, and there is a variety of served final products. This variety of food products, processes and personnel involves makes it crucial to ensure food safety and to maintain an effective food safety management system (Lahou et al. 2012). Efficient food safety prevention program must emphasize personal hygiene and proper handling practices when preparing RTE foods. In order to reduce the risk of food borne illness, food handlers need to be more trained as well as to implement good hygiene practices to improve hygienic conditions and minimize cross-contamination.

Consequently, the intention of the present study was to determine the microbiological quality parameters (aerobic mesophilic count, coliforms, total staphylococci, total yeast and mold count) and the potential food borne pathogens (*E. coli*, *S. aureus* and Salmonella) that can be transmitted to RTE foods at the sale point through food contact surfaces as well as food handler's hands. Furthermore, to fill a knowledge gap concerning the impact of hygienic status of food contact surfaces, handler's hands on the safety level of RTE foods, that can provide food retailers with useful data concerning hygiene regimes and proper surface cleaning to prevent cross-contamination and improve the microbial quality of RTE foods.

MATERIALS AND METHODS

Collection of Samples

Total of 150 composite samples consisting of: (41) swabs of food contact surfaces, (64) swabs of food handler's hands and (45) ready to eat food "RTE" samples were collected from four randomly selected restaurants in Cairo, Egypt, during the period from May, 2019 to February, 2020.

Ethical Approval

The samples were collected after oral approval form the owners and the working employees in the selected restaurants.

Food Contact Surfaces

Swabs from different food contact surfaces (benchtops, cutting boards, serving dishes, ice cream machines, spatula and knives and refrigerators) in the food preparation services of the selected restaurants, were collected as described by ISO (2018) during the daily routine activities for food preparation and production.

- **Food handler's hands:** Gloves and hands of personnel that handled the food products were swabbed according to APHA (2004), with a premoistened sterile swab in sterile saline solution.
- **Ready to eat (RTE) food samples**: RTE food that was prepared by food handlers and ready to be serviced for the consumers (milk shake, ice cream, cheese and cheese-based products, cream and cream-based products, egg-based products and milk-based pastries); were collected according to APHA (2004).

The moistened swabs and food samples were transported to the laboratory in an insulated ice box to be examined microbiologically.

Preparation of the collected samples was applied according to APHA (2004).

Microbiological assessment of the collected samples

- **Total Aerobic Mesophilic Count:** it was adopted according to ISO (2003). As an inoculation medium, duplicate plates of Standard Plate Count Agar (Oxoid, CM0463) were applied with one mL of the original sample and each of the decimal dilutions before incubation for 72 hours at 30°C.
- **Coliform's content (MPN/g):** it was determined according to APHA (2004), using the Most Probable Number (MPN) method. **Isolation of *E. coli*** was carried out according to Feng et al. (2013).
- **Staphylococcal Count:** it was conducted as described by ISO (2003). Duplicate plates of Baird-Parker medium supplemented with egg yolk tellurite emulsion 3.5% (Lab M, LAB085) were inoculated with 0.1mL of each decimal dilution and incubated at 37°C for 48 hours. Isolation and Identification of *S. aureus* were assessed according to Bennett and Lancette (2001).
- **Yeast and Mold count**: It were determined as prescribed by APHA (2004). Duplicate plates of Sabaroud Dextrose Agar (Oxoid, CM0463) were inoculated with one mL of each decimal dilution and incubated at 25°C for 3-5 days.
- **Isolation of Salmonella spp.:** was carried out following ISO (2017). From the original prepared sample, 25mL were aseptically transferred to 225mL of sterile buffered peptone water and incubated at 37°C for 16-20 hours. A loopful from the pre-enriched broth was inoculated into a sterile tube containing 10mL Rappaport Vassiliadis broth, then incubated at 43°C for 24 hours. Dried surface of Xylose Lysin Deoxycholate agar (XLD) was streaked with a loopful from Rappaport Vassiliadis enriched tubes and incubated for 48 hours at 37°C.

Statistical Analysis

SPSS Statistics Version 17.0 software was used for analysis of the obtained data. Kruskal-Wallis *H* and Mann–Whitney *U* tests were used to compare the microbial contamination levels. Pearson correlation (*r*) was performed to assess the relationship between microbial contamination of food contact surfaces and food handler's hand swabs and their impact on the contamination level of RTE food. Chi-square (X^2) test for independence was performed to test the relation between different samples.

RESULTS

Data depicted in Table 1 showed that surface swabs samples have a significant higher content of total aerobic mesophilic bacteria ($7.32\pm6.99\log_{10}$cfu/cm^2), than that of hand swabs samples and RTE food samples (6.89 ± 6.57 and $6.91\pm6.49\log_{10}$cfu/cm^2 or mL, respectively), ($\chi^2(2) = 7.29$, P<0.05; Kruskal-Wallis *H* test). Similarly, the coliform content of surface swabs ($6.89\pm6.58\log_{10}$MPN/cm^2) was significantly higher than that of hand swabs and RTE food samples (6.89 ± 6.57 and $6.91\pm6.49\log_{10}$MPN/cm^2 or mL, respectively), ($\chi^2(2) = 12.32$, P<0.05).

Staphylococcal count of hand swabs samples ($7.18\pm6.15\log_{10}$cfu/cm^2) was higher than that of surfaces swabs ($6.04\pm5.78\log_{10}$cfu/cm^2), (P>0.05); and was higher
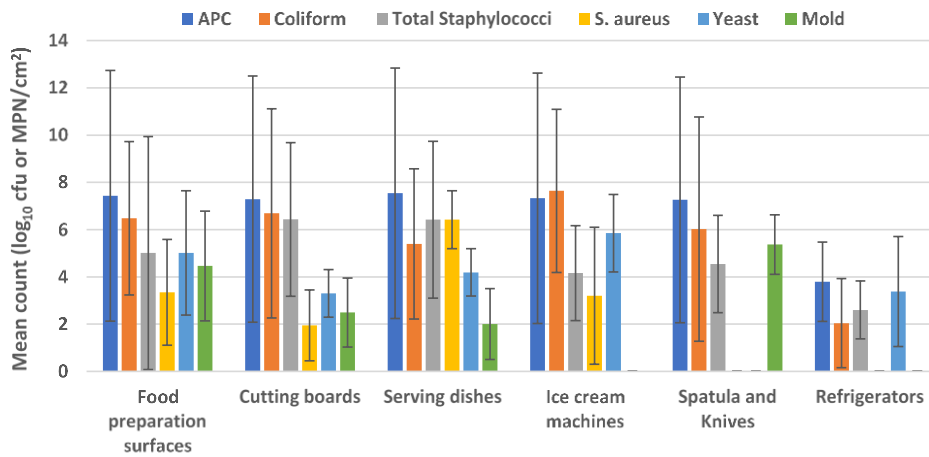
Fig. 1: The mean counts of microbial parameters in the examined Food contact surfaces ($\log_{10}$ cfu or MPN/cm^2). *The obtained results expressed as mean±SE.

Table 1: Prevalence of the microbiological parameters of the examined samples

Examined samples	Positive samples No. (%)	Mean±SEM	Chi square (X^2)	Df	P-value
Total Aerobic Mesophilic Count ($\log_{10}$cfu/cm^2 or g)					
A	38 (92.68)	7.32±6.99	7.29	2	0.026[b]
B	63 (98.44)	6.89±6.57			
C	44 (97.78)	6.91±6.49			
Coliforms count (MPN/cm^2 or g)					
A	29 (70.73)	6.89±6.58	12.32	2	0.002[a]
B	37 (57.81)	6.89±6.57			
C	29 (64.44)	6.46±6.39			
Total Staphylococci count ($\log_{10}$cfu/ cm^2 or g)					
A	34 (82.93)	6.04±5.78	1.65	2	0.438
B	55 (85.94)	7.18±6.15			
C	38 (84.44)	4.83±4.63			
S. aureus count ($\log_{10}$cfu/cm^2 or g)					
A	5 (12.19)	5.66±5.66	4.253	2	0.119
B	20 (31.25)	6.15±6.15			
C	13 (28.89)	2.71±2.37			
Yeast count ($\log_{10}$cfu/cm^2 or g)					
A	29 (70.73)	5.20±4.79	0.696	2	0.706
B	46 (71.88)	5.80±5.74			
C	24 (53.33)	6.71±6.32			
Mold count ($\log_{10}$cfu/cm^2 or g)					
A	7 (17.07)	3.99±3.98	0.314	2	0.855
B	14 (21.88)	4.59±4.41			
C	9 (20)	4.79±4.66			

A= Surface swabs (n=41); B=Hand swabs (n=64); Ready to eat food samples (n=45); [a]Correlation is significant at the 0.01 level (2-tailed); [b]Correlation is significant at the 0.05 level (2-tailed).

than that of RTE food samples (4.83±4.63$\log_{10}$cfu/g). Hand swabs were contaminated with comparatively high incidence of *S. aureus* (31.25%) with mean value of 6.15±6.15$\log_{10}$cfu/cm^2, which was higher than that of surface swabs (5.66±5.66$\log_{10}$cfu/cm^2), and RTE food samples (2.71±2.37$\log_{10}$cfu/g).

The examined samples of surface swabs, hand swabs and RTE food were contaminated with yeast with mean values of (5.20±4.79, 5.8±5.74 and 6.71±6.32$\log_{10}$cfu/cm^2 or g, respectively). Mold contamination of the examined RTE food samples (4.79±4.66$\log_{10}$cfu/g) was higher than that of surface swabs (3.99±3.98$\log_{10}$cfu/cm^2) and hand swabs (4.59±4.41$\log_{10}$cfu/cm^2), respectively.

Findings of Fig. (1) showed the microbial contamination levels of the examined samples of food contact surfaces; the comparatively high counts of total aerobic mesophilic bacteria (7.54±7.54cfu/cm^2), *S. aureus* (3.35±3.24cfu/cm^2), yeast (5.01±4.63cfu/cm^2) and mold (4.46±4.46cfu/cm^2) were recorded in the examined benchtops, while higher levels of coliform (7.64±7.43MPN/cm^2) and staphylococcal count

(6.43±6.25cfu/cm^2) were found in the examined swabs of cutting boards. In contrary, the examined refrigerator swabs have the lowest microbial load in comparison to all examined food contact surfaces.

Results represented in Fig. 2 showed the microbial contamination levels of different RTE food samples, total aerobic bacterial count was high in cheese and cheese-based products (7.39±7.09$\log_{10}$cfu/g) in comparison to other RTE food samples (P>0.05), coliform count was higher in cream and cream-based products (6.91±6.89$\log_{10}$MPN/mL) than the other RTE food samples; except egg-based products that were free from coliform. Amongst all examined RTE foods, milk-based pastries have the highest total Staphylococcal count (5.18±5.09$\log_{10}$cfu/g); and *S. aureus* count (3.17±2.81$\log_{10}$cfu/g). In contrary, *S. aureus* was absent in examined samples of milk shake and ice cream. The egg-based products showed high contamination level of yeast (7.48±7.48$\log_{10}$cfu/g) in comparison to other RTE food samples; while relatively high mold count was detected in cheese and cheese-based products (5.78±5.78$\log_{10}$cfu/g).
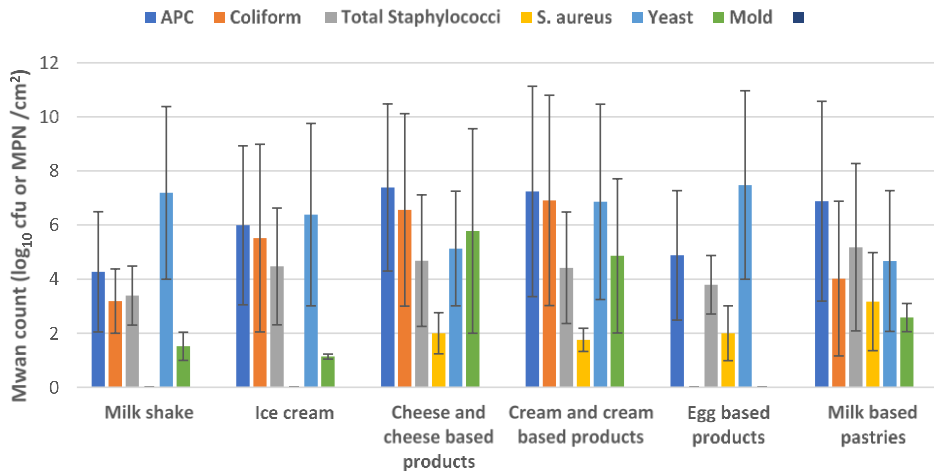
Fig. 2: The mean counts of microbial parameters in the examined RTE food samples (log₁₀ cfu or MPN /cm²). *The obtained results expressed as mean±SE.
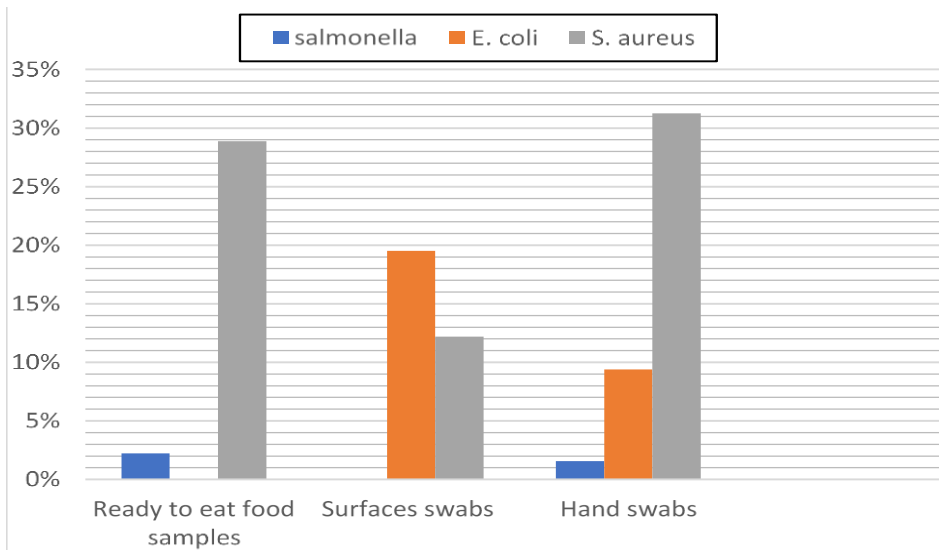

Fig. 3: Prevalence of the isolated pathogens from the examined samples of contact surfaces, handler's hands and RTE food.
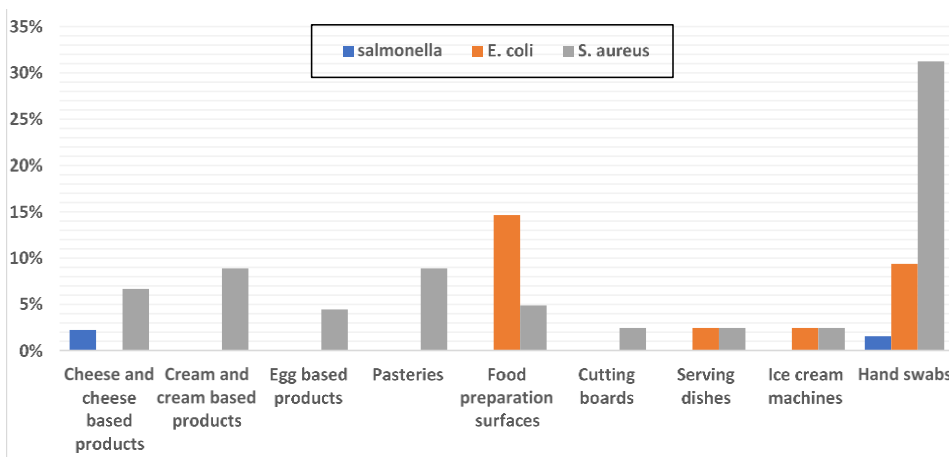

Fig. 4: Incidence of the isolated pathogenic microorganisms from the examined samples.

Results illustrated in Fig. 3 and Fig. 4 showed the prevalence of pathogenic microorganisms isolated from the examined samples; *S. aureus* was the most predominant pathogen isolated from hand swab samples (31.25%), followed by RTE foods (28.89%) and surface swabs (12.19%). Milk based pastries, cream and cream-based products showed the highest incidence of *S. aureus* (8.89%) in comparison to other examined RTE foods, while benchtops exhibited the highest *S. aureus* incidence (4.87%) amongst the examined contact surfaces. *E. coli* was isolated from surface swab samples with percentage (19.51%) higher than that of hand swab samples (9.38%);

otherwise, it was not isolated from the examined RTE food samples. Amongst the examined food contact surfaces, benchtops showed the highest percentage of *E. coli* (14.63%). Salmonella was detected in only one sample (2.20%) of cheese-based products and one sample of hand swabs (1.56%).

Overall, the obtained results revealed the impact of food contact surfaces and handler's hands contamination on the contamination level of RTE food, a strong positive correlation was detected between total bacterial count of surfaces and that of RTE food (r=0.599; P<0.05);similarly there was a strong positive correlation between surface and

RTE food staphylococcal count (r=0.677; P<0.05); and a medium positive association was detected between surface and RTE food yeast content (r= 0.384; P<0.05).

DISCUSSION

Microbiological safety of food is mainly affected by the hygienic practices applied during the food preparation and the sanitation of food contact surfaces. During manufacturing, processing, and preparation of foods, several pathogenic microorganisms are introduced that pose a public health concern (Rane 2011). In the present study, total aerobic microbial count, yeast, and mold counts were selected as quality indicators, coliform and total staphylococci were chosen as hygiene indicators. Foodborne pathogens as *E. coli, S. aureus* and salmonella were evaluated as safety indicators.

Results of the present study revealed significant high microbial contamination of food contact surfaces (P<0.05); benchtops and cutting boards had the worst hygienic status; which was in accordance with Christison et al. (2008) and Sibanyoni and Tabit (2019). The high microbial load of these surfaces can be attributed to the frequent usage of these surfaces in preparation of food, more contact with raw and fresh food materials, and more contact with food handlers on a daily basis during food preparation (Sibanyoni and Tabit 2019).

Additionally, cross-contamination with the food material and the resulting microbial growth in biofilms, improper cleaning and sanitation, and the improper food preparation facilities play an important role in their contamination. In this way, the overall sanitary conditions of these facilities in some RTE food outlets encourages the formation of biofilms on food contact surfaces, which increase the risk of cross-contamination to foods that come into contact with these surfaces. In addition, food handlers lack the necessary skills to manage food safely and the lack or defective food safety management system applied may adversely affect the hygienic status of these food contact surfaces (Sibanyoni and Tabit 2019). The sanitary and hygienic status of food contact surfaces can be assessed by coliform count; high coliform count of the examined samples of contact surfaces indicated poor cleaning standards of these surfaces. Consequently, the effective surface sanitization is needed to prevent the possible harmful effects associated with the contaminated organisms (Christison et al. 2008).

Biofilms formed on food contact surfaces owing to the lack of the hygienic condition, make these surfaces possible sources for foodborne pathogens which may cause foodborne outbreaks. The most prevalent pathogen detected in food contact surfaces was *E. coli*, followed by *S. aureus*. *E. coli* mainly contaminates these surfaces via fecal route (Song et al. 2016); thus, its presence in food contact surfaces indicates fecal contamination (Mengistu and Tolera 2020). *E. coli* can cause a wide variety of infections includes diarrheal illness, dysentery, urinary tract infections, meningitis, sepsis and nosocomial pneumonia. Enterohaemorrhagic *E. coli* (EHEC) is one of the causative agents of food borne diseases; particularly, *E. coli* 0157:H7 cause hemorrhagic colitis and hemolytic uremic syndrome (HUS) with severe abdominal pain and bloody diarrhea mainly in children (Chien et al. 2017). *S.*

aureus can form biofilms on food contact surfaces resist cleaning procedures, which contaminate foods and other food contact surfaces (Azelmad et al. 2017).

It is worth noting that, there is absence of regulatory limits in Egypt for the general hygiene requirements and for the presence of foodborne pathogens on food contact surfaces in RTE food outlets, this made possible isolation of such pathogens from the examined surfaces which can cause foodborne illnesses. Therefore, investigation and monitoring should be applied by the authorities and take immediate corrective actions.

Hand swabs of food handlers showed higher staphylococcal contamination and the highest incidence of coagulase positive *S. aureus,* analogous findings were recorded by Christison et al. (2008), while Soares et al. (2012) reported higher staphylococcal contamination. The presence of Staphylococcal species in most hand swabs and contact surfaces can be attributed to the habitat of staphylococci in nose, skin and hands of human, as well as they are transient microbes acquired from the environment. Thus, food handlers' hands can cross-contaminate food contact surfaces and food products with *S. aureus* during the food preparation and serving (Mohamed et al. 2020). *S. aureus* is known to be a potential human pathogen; it produces heat stable enterotoxins that have been implicated in many foods poisoning cases. Hence, its presence on hands and contact surfaces representing an easy route for human infections via the cross contaminated foods (Oranusi et al. 2013).

The examined hand swabs of food handlers showed also high incidence of coliforms, with possible isolation of *E. coli,* the obtained results were parallel to the findings of Lahou et al. (2012) and Rosmawati et al. (2014). *E. coli* is a member of the family Enterobacteriaceae that normally live in the intestinal tracts of human and animals, its presence indicates direct or indirect fecal contamination from contaminated food contact surfaces including handler's hands.

Fecal contamination, in turn, indicates the possible presence of other harmful organisms, such as salmonella, which is a foodborne pathogen with public health importance. Interestingly, the examined hand swabs were contaminated with Salmonella and that was in agreement with the study performed by Oranusi et al. (2013). Mensah et al. (1999) reported that Salmonella can survive on human hands for more than three hours and can be transmitted to surfaces and foods during packaging or serving. Additionally, Augustin et al. (2020) reported that Campylobacter spp. and non-typhoidal Salmonella implicated in more than 60% of the Food Borne Disease Burden (FBDB). Therefore, particular attention regarding proper personal hygiene especially hand washing after visiting the toilet or touch dirt area with sanitization of the cooking utensils were of great importance (Rosmawati et al. 2014).

Serving of RTE foods with bare hands that increases the level of food contamination is a common practice in most developing countries; consequently, serving stage is recognized as a critical point in the street food industry (Alimi 2016). Unhygienic practices of handling food after production including the absence of hand washing, washing with contaminated water, washing with water but without using detergents or disinfectants, absence of gloves

wearing during slicing of cheese or before the packaging of RTEs; plays a main role in RTE food contamination (Makinde et al. 2020). Therefore, the correct hand-washing procedures applied by food handlers in fast food outlets can decrease hand contamination by 3logcfu or more, which can minimize the risk of cross contamination (Montville et al. 2002).

Several studies reported the contamination of ready to eat foods with pathogens such as *E. coli*, *S. aureus* and salmonella (Oranusi et al. 2013; Othman 2015; Augustin et al. 2020; Ahmed et al. 2020; Gadallah et al. 2020). Consumption of contaminated foods with such pathogens can cause a wide range of adverse health effects for consumers. Epidemiological evidences have implicated food as a vector of pathogenic organisms (CDC 2009); pathogenic bacteria are the major causes of food contamination and food borne disease outbreaks. Consequently, the issue of hygienic quality and safety of RTE foods is continued to be a public health concern that needs to be monitored to safeguard the consumer's health.

Findings of the present study revealed high microbial load of most of the examined RTE food samples, this results were parallel to that reported by Christison et al. (2008) and Fowoyo and Ali (2015). Occurrence of contaminating organisms in food can be attributed to poor personal hygiene by the food handlers, the use of contaminated non potable water, unclean food contact surfaces and unclean environment of the fast-food outlet, in addition to improper temperature control.

Contamination of the examined RTE foods, food contact surfaces and handler's hands with varying degrees of fungal contamination indicates the absence of proper cleaning procedures, improper hygienic measures adopted during production, using food ingredients of bad quality, inadequate refrigeration of food, the surrounding air and packaging materials of food. Contamination of foods with fungi can cause spoilage signs as off-flavor and discoloration that represent an economic loss in addition to the probability of mycotoxins production. Additionally, some yeasts can cause gastrointestinal disturbances, endocarditis, and rarely fatal systemic diseases (Fowoyo and Ali 2015; Oranusi et al. 2011).

The most predominant pathogen isolated from RTE food samples is *S. aureus* followed by Salmonella, while *E. coli* could not be detected, similar results obtained by Lahou et al. (2012) and Muhammad et al. (2016). Contamination of RTE foods with such pathogens can cause foodborne outbreaks (Mengistu and Tolera 2020). The capability of contaminating bacteria to multiply in RTE foods based on several intrinsic (nutrient contents, pH and waster activity) and extrinsic (environmental temperature) factors (Smith and Fratamico 2005). Dairy products, eggs, raw produce and composite dishes were implicated in about (5–20%) of the Food Borne Disease Burden (FBDB). Raw foods (e.g., raw milk, raw milk cheese, raw eggs products, raw meat and raw fish, etc.) contributed to (23–41%) of the FBDB (Oranusi et al. 2013; Mehany et al. 2021).

Amongst all examined RTE food samples, cheese and cheese-based products showed comparatively high microbial count. As cheese is a sliced product, cross contamination with equipment (slicer) could contribute to the high microbial count (Kotzekidou 2013). *S. aureus* was isolated from examined samples of cheese and cheese based products, cream and cream based products and milk based pastries, this finding was comparable to Kotzekidou (2013); Hassanzadazar et al. (2018) and Ahmed et al. (2020). Remarkably, our findings revealed the presence of Salmonella in examined cheese sample. Raw milk cheese considered one of the main foods implicated in salmonellosis. Most Food borne outbreaks of salmonella reported in hospitals, proposed to be associated with Salmonella tainted sandwiches (Batz et al. 2012). Moreover, the antibiotic usage in animals can lead to food contamination with antimicrobial-resistant Salmonella species (Smittle 2000).

The comparatively low microbial contamination level of egg and egg-based products was analogous to that of (Oje et al. 2018). Egg based products as commercial mayonnaise do not support foodborne pathogens growth or survival (Salmonella and *E. coli*) due to the low water activity and pH and the presence of lysozyme in the whole eggs used in their production (Smittle 2000). *S. aureus* was detected in the examined egg-based products, which may be associated with the insufficient cooking, inadequate storage temperature and cross contamination (Fowoyo and Ali 2015; Fahim et al. 2021). Additionally, *S. aureus* can be transported during handling between traders and customers of RTE foods in open-air markets (Amusan et al. 2010).

S. aureus produce extracellular substances which are heat stable enterotoxins that can cause food intoxication and poisoning with symptoms including: nausea, vomiting, abdominal cramp and diarrhea (Mengistu and Tolera 2020). Food and Drug Administration (FDA) reported that *S. aureus* count of more than 10^5cfu/g of the food can produce effective doses of staphylococcal enterotoxins (Anonymous 2009), fortunately, our results of all examined RTE foods were lower than that limit. Proper hand washing with water containing disinfectant and gloves wearing are essential during the food preparation to reduce the excessive contact with the human hands and the subsequent reduction of the contamination with *S. aureus* (Augustin et al. 2020).

Results of the present study revealed a strong positive correlation between microbial contamination of the food contact surfaces and the microbial contamination level of RTE foods. Remarkably, the similar microbial populations which were assessed between the contact surfaces, handlers' hands and ready to eat foods suggested potential cross-contamination from the personnel to food contact surfaces and to foods, and vice versa. Therefore, thorough application of good hygienic practices (GHPs) at the final preparation step could decrease (67–85%) of food borne diseaes, basically, by avoiding cross-contamination, and with a proper storage and cooking which contributed to (60–78%) of the food borne diseae burden reduction (Augustin et al. 2020).

Conclusion

Fast foods are consumed by majority of the population in cities and towns because of the busy lifestyle, and thus it is necessary to be free from microbial contamination as much as possible for ensuring that foods sold are safe and hygienic. Findings of the present study demonstrated microbial contamination of the food contact surfaces and

handler's hands which implicated in the contamination of ready to eat foods, as the study showed a positive correlation between surface contamination and the contamination level of RTE foods, in addition to the similarities in the predominant microbial population of food preparation surfaces, handler's hands and RTE foods. This indicates that these ready-to-eat foods are feasible source of numerous diseases and pose serious health hazards. The potential sources of these contaminants are the unhygienic handling of food, lack of knowledge and training of food handlers and improper cleaning and sanitation programs. Therefore, proper food hygiene, safety systems and the application of Good Manufacturing Practices (GMP) are highly recommended to ensure food safety. Consequently, protect the consumers health and the whole public.

Author's Contribution

All authors shared the ideas and involved in the study design. KM Fahim collected the samples, performed the bacteriological analysis and contributed to the data analysis and interpretation. LI Ahmed and AB Abdel-Salam discussed the results and contributed to the final version of the manuscript. All authors revised and approved the final manuscript.

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