Microbiological Hazards Evaluation of Some Egyptian Falafel Restaurants in Sohag Governorate

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Abstract

The purpose of this study was to identify the presence of some disease-causing bacteria in falafel sandwiches, food handler hands, and food contact surfaces. Random samples were collected from 5 falafel restaurants in Sohag Governorate. As well as applying food safety requirements to control the types of disease-causing bacteria. The results indicated that the total bacterial count (cfu/g) in all restaurants ranged from 5.09 to 6.63 in falafel sandwiches, from 3.02 to 4.69 in hand swabs, and from 3.24 to 4.37 in surface swabs. The *Escherichia coli* in all restaurants ranged from 3.61 to 4.79 cfu/g in falafel sandwiches, from 2.23 to 3.58 cfu/g in hand swabs, and from 2.17 to 2.80 cfu/g in surface swabs. *Staphylococcus aureus* was found in all tested samples, ranging from 2.02 to 3.74 cfu/g in falafel sandwiches, from 2.63 to 5.27 cfu/g in hand swabs, and from 2.57 to 4.53 cfu/g in surface swabs. *Salmonella* was detected in all tested samples of all restaurants, from 2.61 to 2.99 cfu/g in falafel sandwiches, from 2.21 to 3.43 cfu/g in hand swabs, and from 2.31 to 4.00 cfu/g in surface swabs. By applying food safety requirements, the total bacterial count was significantly low and ranged from 1.14 to 2.14 cfu/g. The count of *Staphylococcus aureus* decreased significantly in all samples, and *Escherichia coli* and *Salmonella* were not detected in all tested samples.

Keywords:

Falafel sandwich, hand swab, surface swab, food handler, total bacterial count, *Escherichia coli*, *Staphylococcus aureus* and *Salmonella*. 
INTRODUCTION

Foods that are served in restaurants may get contaminated by microorganisms at any point during preparation, handling, and storage, or even while being served. It can come from contaminated raw materials or cross-contamination from the air, water, dust, human and animal wastes, as well as from many other sources (Osimani et al., 2013). It has been documented that many Ready-to-eat (RTE) vendors in LMICs frequently lack awareness of appropriate hygiene practices, which could make the food more susceptible to microbial contamination (Al Mamun et al., 2013a, b). Food handlers play a crucial role in the transmission of foodborne infections, which has been a long-standing problem in public health. Although there are many ways that bacteria can contaminate food, proliferate, and infect people, it is also possible that these illnesses are spread by the people who handle the food. These food handlers contribute to food contamination in a variety of ways, including by using themselves as a vehicle, preparing food improperly, poor personal hygiene, and contact with cuts, wounds, hair, or mouth. Additionally, soiled surfaces and equipment may have a bigger impact on the burden of foodborne germs (Zain and Naing, 2002; Käferstein, 2003; WHO, 2004; Campos et al., 2009 and Assefa et al., 2015). Escherichia coli's presence indicates improper application of good manufacturing practices (GMPs) during food preparation, which can be directly or indirectly linked to food contamination by faeces (Mohamedin et al., 2015). Lambrechts et al. (2014) said that Coliform bacteria also suggest the presence of other extremely dangerous bacteria, such as Salmonella, Shigella, or E. coli species, such as E. coli O157:H7, which may result in serious systemic infections. Food handlers' poor hygiene habits are closely linked to the presence of Staphylococcus spp. in food samples (Yang et al., 2016; Tomasevic, 2016). Finally, according to the food safety management system separating raw food from RTE food, cleaning surfaces in touch with food, and maintaining personal hygiene are all crucial steps in preventing cross contamination (FSA, 2015). The Hazard analysis and critical control point (HACCP) application has also helped to lower the overall microbial count in food (Tomasevic et al., 2016). Therefore, International standards, such as HACCP, must be implemented by food operators to lower the incidence of foodborne illnesses by monitoring the production of food (Ravishankar et al., 2010). The objective of this study was to evaluate microbiological quality and potential health concerns of some falafel restaurants in Sohag governorate, as well as how to control it by comparing the obtained results with that in the applying case of food safety requirements.

MATERIALS AND METHODS

Materials

Random samples were collected from 5 falafel restaurants (falafel sandwich, food handler hand swab and food contact surface swab) from various restaurants in Sohag governorate to estimate the total bacterial count, Escherichia coli, Staphylococcus aureus and Salmonella bacteria. The collected samples were immediately transferred to the laboratory for testing their suitability for consumption as per the standard specification.

Chemicals

All chemicals used in this study were purchased from Sigma and Al- Gomhoria company. The redistilled water was used.

Methods

Sample preparation:

For falafel sandwiches, 10 g of each sample was combined with 90 ml of sterile solution (9g NaCl/1L distilled water) in a blender. The swabs were placed directly into the solution (9g NaCl/1L distilled water) under sterile conditions to produce a 1/10 dilution. Several types of bacteria were counted using serial dilutions (Mahmoud, 2013). The outcomes are stated as colony forming units (cfu) per gram of sample.

Total bacterial count:

According to A.P.H.A. (1976); Difco (1984); Ahmed (2022), the total bacterial counts were determined using the plate counts
technique on a nutrient ager medium. The plates were incubated for 48 h at 37 °C.

Coliform group bacteria count:
The A.P.H.A. (1976); Difco (1984) and Ahmed (2022), identified a method for determining Coliform group bacteria using MacConkey agar medium. The plates were incubated for 24 h at 37 ±2°C.

Staphylococcus aureus count:
The presence of Staphylococcus aureus was determined using Mannitol salt agar medium, as defined by Difco (1984); Ahmed (2022). The plates were incubated for 24 to 48 h at 37 ±2°C.

Detection of Salmonella:
The presence or absence of Salmonella was determined using Salmonella Shigella agar medium, as defined by FAO (1979); Ahmed (2022). Plates were incubated for 24 h at 35°C. Salmonella emerged as black colonies with metallic sheet on some of them.

Application of domestic frying process:
Food safety requirements have been applied, taking into account optimal conditions and critical control point (frying-serving).

Statistical analysis
The measured data was analyzed for variance using one-way and two-way ANOVA, as required by SAS software. (SAS ver. 9.2, SAS Institute, 2008), according to Gomez and Gomez (1984). The least significant differences (LSD) between means at 5% level of significant for studied parameters, were estimated according to Snedecor and Cochran (1989).

RESULTS AND DISCUSSION
Total bacterial count of falafel sandwiches, hand swabs and surface swabs collected from 5 restaurants:
Results in figure (1) revealed that a significant difference in total bacterial count among the average of falafel sandwiches, hand swabs and surface swabs in all restaurants. For falafel sandwiches, the total bacterial count in the restaurant No.1, 2, 3, 4 and 5 was 5.09, 5.99, 6.63, 5.95 and 5.14 cfu/ g, respectively. The highest total bacterial count was found in restaurant No.3 while, the lowest bacterial count was found in restaurant No.1. New South Wales (NSW) Food Authority (2012) indicated that the total bacterial count in fully cooked RTE foods (falafel sandwiches) should not exceed 5 cfu/ g. Hence, all studied falafel sandwiches samples collected from restaurants are not of good quality according to NSW standard. The increase in the total bacterial count in falafel sandwiches of all restaurants may be due to the food was handled carelessly, contaminated during or after cooking, or was otherwise unclean. Other studies have demonstrated that several surfaces in kitchens can become infected while vegetables are being prepared, and that contaminated bacteria can survive for extended periods of time. Cross contamination may happen in certain circumstances (Gillespie et al., 2000).

The data in the same figure revealed the total bacterial count in the hand swabs taken from food handlers. The total bacterial counts in the restaurant No.1, 2, 3, 4 and 5 were 4.69, 3.53, 3.87, 4.36 and 3.02 cfu/ g, respectively. Regarding hand swabs, the highest total bacterial count was found in restaurant No.1 and the lowest total bacterial count was in restaurant No.5. The presence of total bacterial count in hand swabs may be due to those who handle food wash their hands improperly. This is consistent with Ajao and Atere (2009) findings. Data in the same figure also revealed a significant difference in total bacterial count among surface swabs in all restaurants. The total bacterial count in the restaurant No.1, 2, 3, 4 and 5 were 4.37; 3.50; 3.64; 3.60 and 3.24 cfu/ g, respectively. The highest total bacterial count was found in restaurant No.1 while restaurant No.5 recorded the lowest bacterial count in the surface swabs. The increase in total bacterial count in surface swabs may be due to the cleaning techniques used on surfaces in touch with food are insufficient. This is agreeing with Losito et al. (2017).
Figure (1): Total bacterial count (cfu/g) of falafel sandwiches, hand swabs and surface swabs collected from 5 restaurants.

Total bacterial count in (e) Hand swab (a,b,c) Surface swab (d) Falafel sandwich

*Escherichia coli* of falafel sandwiches, hand swabs and surface swabs collected from 5 restaurants:

The data presented in the figure (2) show significant differences in *Escherichia coli* count among the average of falafel sandwiches, hand swabs and surface swabs in all restaurants. For falafel sandwiches, the *Escherichia coli* count in the restaurant No.1, 2, 3, 4 and 5 was 4.17; 3.88; 3.70; 4.79 and 3.61 cfu/ g, respectively. The restaurant No.4 had a significantly mean *E. coli* count higher than the other restaurants. On the other hand, restaurant No.5 had a relatively lower mean *E. coli* count. *Escherichia coli*’s presence indicates improper application of GMPs during food processing, which can be directly or indirectly linked to food contamination by faces (Mohamedin et al., 2015). In addition, Jay (2005) mentioned that the presence of these organisms in food that is ready to consume indicates that hygienic standards and practices were not followed throughout the production and packaging of this food product. The same figure (2) also revealed *Escherichia coli* count in hand swabs taken from food handlers in all restaurants. Restaurants No.1, 2, 3 and 4 recorded the *E. coli* count as 2.37, 2.47, 3.58 and 2.23 cfu/ g, respectively. Restaurant No.3 had a substantially higher mean *E. coli* count than the other restaurants. However, the *E. coli* was not detected in restaurant No.5. The presence of *E. coli* in samples may be due to contamination during growth has been linked, according to Bichai *et al.* (2008), to the use of contaminated irrigation water. According to Angelillo *et al.* (2000), contamination caused by human handling, the use of contaminated containers or post-harvest washing in contaminated water can increase the prevalence of intestinal infections. Data in the same figure shows the surface swabs examine in contact with food in all restaurants. Restaurants recorded the *E. coli* count in restaurant No.1, 2, 3, 4 and 5 as 2.80, 2.49, 2.62, 2.17 and 2.36 cfu/ g, respectively. Restaurant No.1 had the highest count of *E. coli* compared to other restaurants, whereas restaurant No.4 had the lowest count of *E. coli*. These results are consistent with
Mohamedin et al. (2015) they stated that surfaces in contact with ready-to-eat food may be contaminated with \( E. \) coli through the contaminated water used.

**Figure (2):** *Escherichia Coli* bacteria (cfu/g) of falafel sandwiches, hand swabs and surface swabs collected from 5 restaurants.

*Escherichia Coli* count in (b,d,e,f) Falafel sandwich   (c) Surface swab   (a)Hand swab

**Staphylococcus aureus** of falafel sandwiches, hand swabs and surface swabs collected from 5 restaurants:

There was a significant difference in *Staphylococcus aureus* count among the average of falafel sandwiches, hand swabs and surface swabs taken from all restaurants. For falafel sandwiches, restaurants No.1, 2, 3, 4 and 5 recorded *Staphylococcus aureus* count was 3.31, 3.74, 2.95, 3.65 and 2.02 cfu/ g, respectively. The restaurant No.2 had the highest mean *Staphylococcus aureus* count (3.74 cfu/ g). Restaurant No.5 had a much lower mean *Staphylococcus aureus* compared to the other restaurants (2.02 cfu/ g). Burt et al. (2016) asserted that *S. aureus* enters human food through the skin, open wounds, and respiratory passages. Since it is still present in cooked RTE foods, customers may be exposed to numerous health concerns. Thus, depending on how much contaminated food was eaten and how susceptible an individual was to the toxin, different symptoms may show up. *Staphylococcal* food poisoning can cause vomiting, nausea, diarrhea, and stomach pain among other symptoms (Amusan et al., 2010). The data in the same figure (3) revealed a significant difference in *Staphylococcus aureus* count among hand swabs taken from food handlers. Restaurants No.1, 2, 3, 4 and 5 recorded *Staphylococcus aureus* count as 5.27, 3.46, 3.44, 2.98 and 2.63 cfu/ g, respectively. The restaurant No.1 had a significantly higher mean *Staph aureus* count than the other restaurants. The presence of *Staph aureus* in hand swabs may be due to the fact that *Staphylococcus* species are resident flora of human skin and hence easily contaminate surfaces on touch could be the cause of their prevalence in all hand swabs and easy-contact surfaces (Oranusi and Olorunfemi, 2011; Oranusi and Braide, 2012). Data in the same
figure also shows a significant difference in *Staphylococcus aureus* count among surface swabs taken from the food contact surfaces in the 5 restaurants. Restaurant No.4 had a significantly higher mean *Staph aureus* count (4.53 cfu/g) than the other restaurants. Restaurant No.5 had the lowest count of *Staph aureus* (2.57 cfu/g) compared to the other restaurants. Studies have shown that harmful bacteria such *S. aureus* can survive on surfaces in contact with food for an extended period time, increasing the risk of foodborne diseases (Kusumaningrum et al., 2003).

![Staphylococcus Aureus Count](image)

Figure (3): *Staphylococcus aureus* count of falafel sandwiches, hand swabs and surface swabs collected from 5 restaurants.

*Staphylococcus aureus* count in (b,f) Surface swab (a,c,e) Hand swab (d) Falafel sandwich

**Salmonella of falafel sandwiches, hand swabs and surface swabs collected from 5 restaurants:**

The data presented in figure (4) illustrate significant differences in *Salmonella* count among the average of falafel sandwiches, hand swabs and surface swabs in all restaurants. For falafel sandwiches, the *Salmonella* count in the restaurant No.1, 2, 3, 4 and 5 recorded 2.77, 2.99, 2.89, 2.61 and 2.86 cfu/g, respectively. Restaurant No.2 had the highest mean *Salmonella* count compared to the other restaurants; however, restaurant No.4 had a relatively lower. The Agency (2009) indicated that the *Salmonella* count in ready-to-eat food must be free of *Salmonella* (0 cfu/g). All falafel sandwich in all restaurants exceeded the permissible limits from the collected samples. This increase in *Salmonella* count in falafel sandwich may be due to the primary source of the *Salmonella* spp. contamination of those sandwiches was the green salad. This finding is consistent with observations made by El-Gazaly and Ahmed (2003), and Salem (2004) that *Salmonella* can survive for several days in vegetables like tomatoes and celery. According to Odu and Akano (2012), food vendors' poor manufacturing practices may be the cause of pollution. Because these microorganisms are known to cause food poisoning and food borne illnesses, this is a public health problem. Data in the same figure revealed *Salmonella* count in hand swabs taken from food handlers in all restaurants. The *Salmonella* count in restaurant
No.1, 2, 3, 4 and 5 recorded 2.49, 2.21, 3.43, 2.35 and 2.53 cfu/ g, respectively. Restaurant No.3 had a substantially higher mean *Salmonella* count than the other restaurants. Restaurant No.2 had a much lower mean *Salmonella* count. The presence of *Salmonella* count in hand swabs may be due to *S. typhi* is typically spread through food or water that has been contaminated with human faces. Carriers who work as public food handlers or health care providers can pose a major threat to the public's health. This is consistent with Easa (2010) findings. Data in the same figure also shows a significant difference in *Salmonella* count among surface swabs taken from the food contact surfaces in the 5 restaurants. Restaurant No.1 had a significantly higher mean *Salmonella* count (4.00 cfu/ g) than the other restaurants. Restaurant No.5 had the lowest count of *Salmonella* (2.31 cfu/ g). The Agency (2009) indicated that the *Salmonella* count on surface must be free of *Salmonella* (0 cfu/ g). All the samples exceeded the permissible limit. The increase in *Salmonella* count in surface swab may be due to the existence of significant cross-contamination among the contact surfaces during the operation may be indicated by the elevated microbiological load discovered on the contact surface Ayalew et al., (2015). In general, most of the samples that were looked into investigated tended to have pathogenic counts that were higher than the recommended safety level put forward by the Egyptian Organization for Standardization and Quality Control (EOSQC), indicating that those foods may be dangerous enough to be fed to humans. Fast food should therefore be avoided outside and replaced with other, healthier dishes (Awad-Allah and Mostafa, 2008).

Figure (4): Salmonella of falafel sandwiches, hand swabs and surface swabs collected from 5 restaurants. Salmonella count in (f) Hand swab (b, a, d, e) Falafel sandwich (c) Surface swab
Microbiological evaluation of the applied part at domestic:

The data in the figure (5) showed significant differences in total bacterial count among the average of falafel sandwich, hand swab and surface swab. The highest total bacterial count in falafel sandwich was 2.14 cfu/g, and the lowest total bacterial count was found in hand swab (1.14 cfu/g). New South Wales (NSW) Food Authority (2012) Indicated that the total bacterial count in fully cooked ready-to-eat foods (falafel sandwiches) should not exceed 5 cfu/ g. Thus, all tested samples did not exceed the permissible limit. This may be due to hand washing, and surface disinfection before preparing food. These results are in agreement with Dodrill et al. (2011), who stated that Effective hand washing, and surface sanitization will help avoid any negative impacts from these organisms may have. Therefore, samples had the lowest microbial count after application of GMP, decreased by 100% compared to the previous one after applying the HACCP system. This is consistent with Kassem et al. (2004). The data in the same figure revealed differences in Staphylococcus aureus count among the average of falafel sandwich, hand swab and surface swab. The reason for the decrease in the Staphylococcus aureus count may be due to good hand washing, surface cleaning and the application of GMP because the fact that Staphylococcus species are resident flora of human skin and hence easily contaminate surfaces on touch could be the cause of their prevalence in all hand swabs and easy-contact surfaces (Oranusi and Olorunfemi, 2011; Oranusi and Braide, 2012). Escherichia Coli and Salmonella were not detected in all samples tested. This result was also consistent with the presence of Agency (2009) which indicated that RTE should be free of Salmonella. The absence of these organisms in the RTE food and swabs samples tested indicates that hygienic standards and practices were followed during the production of this food product (Jay, 2005). Additionally, according to Antwi-Agyei and Maalekuu (2014), heating meals with good hygienic practice (GHP) could help reduce the microbial load to a harmless level.

CONCLUSION

Because fried foods are sold in Egyptian restaurants and street vendors, they are sensitive to microbiological deterioration, so the world health organization defined the HACCP program for the prevention of foodborne diseases about 20 years ago because it increases food safety. The application of the HACCP system in the process of frying foods greatly helped to reduce the microbial load by following the Good Manufacturing Practice (GMP) and the Good Health Affairs Practice (GHP) (following food safety requirements such as washing and drying hands, cleaning and disinfecting surfaces).

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تقييم المخاطر الميكروبيولوجية لبعض مطاعم الفلافل المصرية بمحافظة سوهاج

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الملخص العربي

هدفت هذه الدراسة إلى التعرف على وجود البكتيريا المسببة للأمراض في سندوتشات الفلافل، ومسحات أيدي متناولي الطعام، ومسحات الأسطح الملامسة بالأغذية التي تم الحصول عليها من 5 مطاعم فلائل، وكذلك تطبيق اشتراطات سلامة الغذاء للسيطرة على أنواع البكتيريا المسببة للأمراض. تم جمع العينات عشوائياً وتحت ظروف محكمة من مطاعم الفلافل في محافظة سوهاج. أشارت النتائج إلى أن العدد الإجمالي للبكتيريا في جميع المطاعم تراوح من 5.09 إلى 6.63 مستعمرة / جرام في سندوتشات الفلافل، ومن 3.02 إلى 4.69 مستعمرة / جرام في مسحات اليد، ومن 3.24 إلى 4.79 مستعمرة / جرام في مسحات الأسطح. وتراوحت نسبة الإشريشيا الفولونية في جميع المطاعم من 2.23 إلى 3.58 مستعمرة / جرام في سندوتشات الفلافل، ومن 2.17 إلى 2.80 مستعمرة / جرام في مسحات اليد، ومن 2.21 إلى 4.37 مستعمرة / جرام في مسحات الأسطح. تم العثور على المكورات العنقودية الذهبية في جميع العينات التي تم اختبارها، حيث تراوحت من 2.02 إلى 3.74 مستعمرة / جرام في سندوتشات الفلافل، ومن 2.63 إلى 5.27 مستعمرة / جرام في مسحات اليد، ومن 2.57 إلى 4.53 مستعمرة / جرام في مسحات السطح. تم الكشف عن وجود السالمونيلا في جميع العينات التي تم اختبارها في جميع المطاعم، حيث تراوحت من 3.61 إلى 3.74 مستعمرة / جرام في سندوتشات الفلافل، ومن 2.14 إلى 3.43 مستعمرة / جرام في مسحات اليد، ومن 2.31 إلى 4.00 مستعمرة / جرام في مسحات السطح. ومن خلال تطبيق متطلبات سلامة الأغذية، كان إجمالي عدد البكتيريا مخفضاً بشكل ملحوظ وتراوح من 1.14 إلى 2.14 مستعمرة / جرام. انخفض عدد المكورات العنقودية الذهبية بشكل ملحوظ في جميع العينات، ولم يتم اكتشاف الإشريشيا الفولونية والسالمونيلا في جميع العينات التي تم اختبارها.