Experimental infection in mice with *Acremonium* spp. mold and *Rhodotorula* spp. yeast isolated from cow's milk

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Abstract

This study was performed in isolation of some pathogenic fungi from milk of apparently healthy cows. Eighty milk samples were collected from four quarters of twenty cows in the Abu Ghraib. Each sample was cultured on Sabouraud dextrose Agar at 28±2 ºC for 4-7 days. The most predominant mold and yeast were *Acremonium* spp. and *Rhodotorula* spp. that had used in the experimental infection. The number of experimental mice used in this study was 30 which divided into three equal groups. The 1st group was infected with *Acremonium* spp. by injection of 0.2 ml of $2\times10^7$ conidia/ml intraperitoneally. The 2nd group was inoculated with same dose and route with *Rhodotorula* spp., while the 3rd group served as control group. All mice were sacrificed after 2 weeks of injection, Serum was obtained for biochemical analysis of hepatic and renal enzymes. Some of internal organs of infected groups were taken for histopathological study. The result recorded that the total percentage of fungal infection was 53 (66.3%) of these *Acremonium* spp. 9 (24.3%) and *Rhodotorula* spp. 7 (43.8%). Histopathological sections of the 1st group showed severe lesions in kidney than 2nd group although both groups showed lesions in most internal organs. Blood biochemical results showed the yeast has highest significant differences on ALT levels, while the mold has highest effect on serum creatinine, with insignificant difference on urea. In conclusion it could be said that in spite of *Acremonium* spp. and *Rhodotorula* spp. are considered as contaminant fungi, but they can cause disseminated mycosis in mice.

Keywords: Opportunistic fungi, Bovine mastitis, ALT, Creatinine

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الإصابة التجريبية في الفئران بعفن *Acremonium* spp. وخميرة *Rhodotorula* spp. المعزولتان من حليب البقر

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الخلاصة

أجريت هذه الدراسة لعزل بعض أنواع الفطريات المرضية من حليب الأبقار السليمة ظاهريا. جمعت ٨٠ عينة حليب من ستوراء الأربعة إلى ٢٠ بقرة من منطقة حزام أبو غريب ووزعت على وسط السأبرودك دكسترول الصلب بدرجة حرارة 28±2 ºC لمدة ٤-٧ أيام. سجلت نسبة عزل عفنية عالية وصلت إلى ٨٩.٦١% وكان من أكثر الأعفان وخميرة شيوعا هو عفن *Acremonium* spp. ١٦.٩٨% وخميرة *Rhodotorula* spp. ١٣٢% اللذان تم استخدامهما في أحداث الإصابة التجريبية تم خلال ٣ فائرا قسموا إلى ٣ مجاميع بالتساوي. سمحت المجموعة الأولى بالعفن *Acremonium* spp. وخميرة *Rhodotorula* spp. بالتسبب في الأضرار الضائعة، بينما أقيمت المجموعة الثالثة كمجموعة سليمة. تم تحضير الخيوطات بعد أسبوعين من الحقن وتم الحصول على المصل وبعض الأعضاء الداخلية من المجاميع المخصمة لدراسة التغيرات المرضية النسبية. بينت المجموعة الأولى إصابة حادة أقوى في الكلية مقارنة بالمجموعة الثانية التي أظهرت إصابة أقوى في الكبد على الرغم من إن المجموعتين
**Introduction**

On one hand, milk and its products are considered as one of the major important sources in the human diet because it contained numerous essential components like vitamins, calcium, minerals and fatty acids (1,2). On the other hand, milk may during udder infection plays an important role in transmission of the different microbes that cause the subclinical mastitis (SCM) in non-obvious changes occur in the manifestations of the milk and udder compared with clinical mastitis (3). And still represents a source of infection to healthy animals (4-7). In the dairy cattle and buffaloes, the prevalence of mastitis may exceed 50% to 15-40 more times the incidence of subclinical mastitis than clinical mastitis (8).

Many previous studies performed for detecting of clinical mastitis with the efforts for treatment through performing antibiotic sensitivity test especially case of bacterial infection (9,10). Regarding mycotic mastitis, more attention was given to the pathogenic fungi causing mastitis, but lower researches are dealing with saprophytic or opportunistic fungi as probable causes of clinical or subclinical mastitis (11-13).

Therefore, the objective of the present study is to elucidate the possible role of saprophytic fungi in causing systemic fungal infection in mice through their effect on liver and kidney enzymes and through other histopathological changes in internal organs.

**Materials and methods**

**Source of samples**

The number of milk samples collected from four quarters of twenty cows which appeared healthy from Abu Ghraib zone was 80. The period of this study was starting from 5 November 2017 to 25 January 2018, by cleaning the teat end zone was 80. The period of this study was starting from 5

The present study showed a high percentage of fungal contamination in the milk samples of apparently healthy cows. The total fungal isolates which gave the positive result was 53 (66.25%) that were tabulated into 2 types: 7 mold species 37 (69.8%) and 3 yeast species 16 (30.1%) (Table 1). The current study revealed that the fungal contamination of the milk samples was caused by molds more than yeasts (Tables 2 and 3). The result shown in tables 2 and 3 revealed that the most predominant mold and yeast were *Acremonium* spp. 9 (24.3%) and *Rhodotorula* spp. 7 (43.8%), respectively, those were used in the experimental animal to study their effects on the internal organs of mice and their biochemical alteration in the hepatic and renal enzymes.

Table 1: Prevalence of fungal contamination in cow's milk samples
| Type        | No. of spp. | No. of isolates | %  | Total fungal isolates |
|-------------|-------------|-----------------|----|-----------------------|
| Mold        | 7           | 37              | 69.8 | 53/80 (66.25%)        |
| Yeast       | 3           | 16              | 30.1 |                       |

Table 2: Type of molds that contaminated milk samples

| Type of mold      | No. of isolates | Percentage % |
|-------------------|-----------------|--------------|
| *A. flavus*       | 5               | 13.5%        |
| *A. niger*        | 4               | 10.8%        |
| *A. fumigatus*    | 3               | 8.1%         |
| *Alternaria* spp. | 3               | 8.1%         |
| *Acremonium* spp. | 9               | 24.3%        |
| *Curvularia* spp. | 3               | 8.1%         |
| *Fusarium* spp.   | 2               | 5.5%         |
| *Geotricum* spp.  | 4               | 10.8%        |
| *Rhizopus* spp.   | 4               | 10.8%        |
| **Total**         | **37**          | **100%**     |

Table 3: Type of yeasts contaminated milk samples

| Type of yeast       | No. of isolates | Percentage % |
|---------------------|-----------------|--------------|
| Cryptococcus spp.   | 4               | 25%          |
| *C. albicans*       | 5               | 31.2%        |
| *Rhodotorula* spp. | 7               | 43.8%        |
| **Total**           | **16**          | **100%**     |

**Histopathology**

Histological sections of the internal organs of inoculated group of mice with *Acremonium* spp. show severe histological changes than those inoculated with *Rhodotorula* spp. In respect to those changes in spleen of mice inoculated with *Acremonium* spp. for two weeks revealed lymphocytic depletion and infiltration of the inflammatory cells and macrophages with the presence of the hemosiderin pigment (Figure 1). In the intestine, there was hyperplasia of the goblet cells and infiltration of the inflammatory cells (Figure 2). Liver showed the necrosis in hepatocytes and infiltration of the inflammatory cells in the liver parenchyma (Figure 3), and there was an infiltration of the inflammatory cells between myocardial fibers of myocardium (Figure 4). The histopathological examination of the inoculated mice with *Rhodotorula* spp. after two weeks showed lesions multifocal lymphocytic aggregation and macrophages scattered throughout the parenchyma with vacuolation of hepatocytes cytoplasm of liver (Figure 5). In the myocardium, there was infiltration of the inflammatory cells between dilated myocardial fibers (Figure 6). The kidney showed periglomerular edema, acute cell swelling of the renal tubules and infiltration of the inflammatory cells in the renal parenchyma (Figure 7). Intestine showed infiltration of the inflammatory cells of mucosa and sub mucosa (Figure 8).
Figure 3: The histopathological changes in the liver of the inoculated mice with *Acremonium* spp. after two weeks shows necrosis in the hepatocytes and infiltration of the inflammatory cells in the liver parenchyma (red arrow). H&E stain, 400x.

Figure 4: The histopathological changes in the myocardium of the inoculated mice with *Acremonium* spp. after two weeks shows infiltration of the inflammatory cells between the myocardial fibers (red arrow). H&E stain, 400x.

Figure 5: The histopathological changes in the liver of the inoculated mice with *Rhodotorula* spp. after two weeks shows inflammatory infiltrations formed from lymphocytes and macrophages scattered throughout the parenchyma with vacuolation of the hepatocyte's cytoplasm (red arrow). H&E stain, 400x.

Figure 6: The histopathological changes in the myocardium of the inoculated mice with *Rhodotorula* spp. after two weeks shows infiltration of the inflammatory cells between the dilated myocardial fibers (red arrow). H&E stain, 400x.

**Biochemical tests**

The effect of *Acremonium* and *Rhodotorula* spp. inoculation in mice on liver and kidney enzymes showed highly significant differences compared with control group. Based on LSD analysis the *Rhodotorula* spp. has the highest effect on ALT levels (*P*=0.0001), while the mold has the highest effect on serum creatinine and most significant statistical difference (*P*=0.0038), with insignificant difference on serum urea (*P*=0.0462) (Table 4).
Figure 7: The histopathological changes in the kidney of the inoculated mice with *Rhodotorula* spp. after two weeks shows periglomerular edema, acute cell swelling of the renal tubule's infiltration of the inflammatory cells in the renal parenchyma (red arrow). H&E stain, 400x.

Figure 8: The histopathological changes in the intestine of the inoculated mice with *Rhodotorula* spp. after two weeks shows mild enteritis and manifested by infiltration of the inflammatory cells of mucosa and sub mucosa (red arrow). H&E stain, 100x.

Table 4: Effect of *Acremonium* and *Rhodoterella* spp. inoculation on enzymes of liver and kidney in mice after two weeks of inoculation intraperitoneally

| Groups               | Mean ± SE          |
|----------------------|--------------------|
|                      | ALT (U/L) | Creatinine (µmol/L) | Urea (µmol/L) |
| G1 *Acremonium* spp. | 24.80 ± 2.47 b    | 0.744 ± 0.07 a      | 33.58 ± 1.76 a |
| G2 *Rhodotorula* spp.| 11.73 ± 1.24 c    | 0.540 ± 0.03 b      | 28.55 ± 1.90 b |
| G3 (Control)         | 40.20 ± 1.33 a    | 0.514 ± 0.02 b      | 30.68 ± 1.75 ab |
| LSD value            | 5.142 *          | 0.139 *             | 4.250          |
| P value              | 0.0001           | 0.0038              | 0.0462         |

Different letters in the same column are significantly different, P<0.05.

**Discussion**

The present study appeared that the percentage of the mold contamination of milk samples was 69.8% taken from a healthy cow. The high percent of mold in milk may be due to bad management or even lack of hygiene in that rural area. This opinion coincides with the Luaibi *et al.* (21), most of the contaminated fungi are considered as saprophytic and habitat in soil and vegetation but when there is stress or defect in the defense mechanism of the udder, the isolation of these fungi can be discovered, this fact was highlighted by Zhou *et al.* (22). The type of milking using in this area is the manual milking which participates in introducing of the conidia into the udder through the contaminated teat and the teat canal by the workers contaminated hands. The previous study found that the fungal contamination of milk could reach to 46.15% with the manual milking with partially lower 44.70% percentage by machine milking (23).

The current study revealed that the most predominant mold was *Acremonium* spp. constitute large genera of polyphyletic fungi due to its containing about 150 species, most of them habitat and isolated from soil and plant debris and could cause pathogenic infection to plant (18). The food-borne pathogens play an important role to infect human and animals (24). On the other hand, it can result in localized infection through traumatic contamination such as mycetoma, onychomycosis, keratitis (25) and in rare cases disseminated infection in immunosuppressed host (26-28). The most organs affected were spleen, liver and kidney. which coincide with the finding of Fernandez Silva *et al.* (18) how described the lesion in spleen, kidney and liver while the least organ affected was the brain. There are few reports about the systemic infection with *Acremonium* spp. But Nedret Koç (29) could isolate *Acremonium strictum* with *S. aureus* from the pleural fluid in case of colon adenocarcinoma. However, most these researches pointed to this type of fungi associated with the immunocompromised hosts particularly after chemotherapy, in post-transplantation period and in the patients with primary immunodeficiency. Fakharian *et al.* (30) and even Fernandez...
Silva et al. (16) revealed to the histopathological changes of liver and kidney in immunosuppressed mice, interestingly, the finding of the current study appeared in immunosuppressed mice, this indicate that the fungus has different types of the virulence factors that could lead to induction of the pathological alteration in some of the internal organs.

In concerning of contaminated milk with yeasts, the present study recorded the rate of yeast isolated from cow’s milk was 30.1%. This result could be attributed to multifactor such as the presence of irritation in milk ducts and alveoli, injury in milk sinus, intramammary administration of antibiotic particularly for long period in case of bacterial infection and the virulence factors of the pathogen. All these factors are related to yeast infections of the udder, the previously study revealed that the incidence of bovine mycotic mastitis caused by yeast in Poland and found the Rhodotorula spp. occupy the third position after Candida and Trichosporon spp. (31). In addition, the investigation of the current study disagree with Akdouche et al. (23) who recorded the highest incidence of bovine mycotic mastitis caused by yeast and this difference may be due to the season of the sample collection especially during winter and spring when the yeast isolation is abundant compared to summer the samples of the present study were collected are least.

This study had been recorded a high ratio of Rhodotorula spp. isolation 7 (43.8%) when compared with other yeasts as Candida and Cryptococcus spp. and this percentage was higher than reported by Wawron et al. (31) and Hasan and Yassein (32) 9.3% and 7.5%, respectively. Rhodotorula spp. are common airborne contaminant fungi and can be isolated from the soil, and in spite of consideration as normal habitats of the skin, urine and feces in human, It associated with invasive mycosis through the catheter, endocarditis, keratomycosis, peritonitis and meningitis among the immunocompromised hosts because these species have emerged as opportunistic fungi in those hosts (33,34).

In the past, Rhodotorula spp. considered as one of non-virulent yeast whereas at the last two decades, it was found there were increasing in the number of infections that caused by Rhodotorula spp. (35). So, the present study is considered as the first one that described the experimental model of disseminated Rhodotulosis in mice liver when compared with other organ. This evidence is in consistence with Wirth and Goldani (35) who studied the infection of this yeast in rats and found that the liver showed sever degree of infection. Also, this evidence was corresponding with the abnormalities of chemistry analysis represented by significant differences in ALT associated with the organ damage.

**Conclusion**

Based on current findings, it can be concluded that in spite of Acremonium spp. and Rhodotorula spp. are considered as saprophytic fungi, but they can result in disseminated mycosis in mice after intraocular inoculation of these pathogens.

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