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# Evaluation of the mycological status of luncheon meat with special reference to aflatoxigenic moulds and aflatoxin residues

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**Abstract**

The luncheon meat samples analyzed, which were produced locally by the two main luncheon meat producing companies in Egypt were relatively highly contaminated either by moulds and yeasts in general, aflatoxigenic species and aflatoxin residues in particular. The most frequently encountered fungi from the samples were yeasts, *Aspergillus niger*, *A. flavus*, *Penicillium chrysogenum*, *Rhizopus stolonifer*, *Mucor circinelloides*. Less common were *Cladosporium sphaerospermum*, *Alternaria alternata*, *Mycosphaerella tassiana*, *P. aurantiogriseum* and *P. oxalicum*. The most important aflatoxigenic species, *A. flavus*, was isolated frequently. It was 10% of the total fungal isolates from both samples of the two companies. Seven luncheon meat samples out of 50 analyzed were positive for aflatoxin $B_1$ or $B_1$ and $G_1$, while all samples were negative for aflatoxins $B_2$, $G_2$, $M_1$ and $M_2$. Aflatoxin $B_1$ was detected only in 4 and 3 samples out of 25 analyzed from each of company A and B, respectively. The highest detectable level, 11.1 ppb, was recorded in a sample from company B and the least, 0.5 ppb, in a sample from company A. Aflatoxin $G_1$, at concentration of 3.2 ppb, was detected in only one sample of the aflatoxin $B_1$ – contaminated 3 samples of company B: this sample also had the highest level of aflatoxin $B_1$. Some luncheon meat samples had higher numbers of aflatoxigenic *A. flavus* than others, however these samples were negative for aflatoxins. The hazardous potential of such contamination will be discussed.

**Key words:** aflatoxin residues, *Aspergillus flavus*, luncheon meat, moulds

## Introduction

Moulds can contaminate and cause considerable economic loss through spoilage and discoloration of foods. Also, world attention had been focused in the last three decades on the toxicity of some moulds, which are a considerable hazard to health associated with liver damage and carcinogenicity [1].

Aflatoxigenic moulds were first reported in 1963 to be present in U.S. agricultural commodities used for human food [2].

Toxic mould metabolites, mycotoxins, are a broad spectrum of biologically active substances that occur as a result of growth of saprophytic moulds on various types of feed and foods. Aflatoxins are the most important mycotoxins and pose a quadruple threat to both human and animals as they produce four distinct effects: acute liver damage, liver cirrhosis, induction of tumors and teratogenic effects [3–6]. Residues of these toxins in animal tissues and their products is a public health concern.

Luncheon meats usually consist of finely chopped meat and fat with or without some added cereals, cured with salt and nitrite and heat processed [7].

In Egypt, information concerning moulds, aflatoxigenic moulds and aflatoxins from animal products is relatively incomplete. Therefore, this investigation was planned to determine the contamination level of luncheon meat, a product widely consumed in Egypt, by spoilage fungi and yeasts with special reference to aflatoxigenic species and aflatoxin residues.

## Materials and methods

Fifty random samples of luncheon meat were collected from Assiut city markets. These were locally produced by the two main luncheon meat-producing companies in Egypt, coded herein by A and B, with 25 samples from each. The samples were kept in the freezer in separate clean polyethylene bags until mycological and aflatoxin analyses were conducted.

### *Mycological analysis*

For detecting, enumerating and isolating fungi, all luncheon samples have been examined on dichloranrose bengal medium of King et al. [8] using direct plating technique [6] as follows: 15 segments, approximately 10 mm square each, from each luncheon meat sample were placed asceptically on the surface of the agar medium, 5 segments per plate. The plates were then incubated at 25 °C for 7–10 days. The fungal colonies were counted, isolated and identified. The identification were based on macroscopic and microscopic characteristics according to [6, 9–18].

### *Aflatoxin analysis*

Fifty grams of each luncheon meat sample was minced asceptically and separately and analyzed for aflatoxin residues by the method of the Association of Official Analytical Chemists [19]. Statistical analysis of the data was performed according to Kalton [20].

## Results and discussions

### *Spoilage mycoflora associated with luncheon meat samples*

Twenty seven genera and 46 species were isolated from 50 luncheon meat samples from the two major producing-companies in Egypt; 22 genera and 36 species of moulds from samples of company A and 20 genera and 33 species from samples of company B (Table 1).

The mean, standard deviation, minimum and maximum numbers of isolates of the most commonly encountered genera and species from luncheon meat of the two companies under investigation are presented in Table 2. At the same time, the percentages for the number of contaminated luncheon meat segments are also presented in Table 2. The number of isolates of fungi and the most common species in the individual samples are shown in Table 3.

*Aspergillus* species, 21.5% and 26.3% of the total isolates recovered from the samples of the two companies A and B, respectively, *Penicillium* species, 18.7 and 12.6, and yeasts, 23.3 and 25.1, were isolated in high frequencies. *Aspergillus* species were recorded in 100% and 100% of the samples from the two companies, *Pencillium* species 96% and 88%; and yeasts from 84% and 88% of the samples of the two companies, respectively. Similar results have been reported by Abdel-Rahman et al. [21] who found that *Penicillium*, yeasts and *Aspergillus* were the most encountered from luncheon meat.

*A. flavus*,10.3% and 10.5% of the total isolates, and *A. niger* (9.8% and 13.2%) were the most commonly encountered species of *Aspergillus*. Of *Penicillium* species only *P. chrysogenum*, 12.2% and 7.1%, was isolated at a high frequency; however, *P. aurantiogriseum*, 3.4% and 1.6%, was found moderately in samples of both companies. *P. oxalicum* isolates were of low occurrence in samples of company A and of moderate occurrence in samples from company B. The remaining 6 *Aspergillus* species and 5 *Penicillium* species were less frequent (Table 1). Some of these species were only isolated from luncheon meat of company A, *A. oryzae*, *P. janczewskii*, *P. solitum*, *P. variabile*, while other species, *A. melleus* and *A. sydowii*, were frequent only from luncheon meat of company B.

Abdel-Rahman et al. [21] isolated only 3 *Aspergillus* species of which *A. flavus* was the most common followed by *A. niger* and *A. sydowii*. However, they isolated 7 *Penicillium* species of which *P. verrucosum* var. *cyclopium* (= *P. aurantiogriseum*), *P. citrinum*, and *P. italicum* were the most common. Roushdy et al. [22] obtained a few fungi from luncheon meat, *Aspergillus niger* and *A. flavus* being the most common, also *Penicillium verrucosum*, *Mucor* spp. and *A. ochraceus*. Many *Aspergillus* and *Penicillium* species have been previously reported from other meat products such as minced meat and basterma [21], sausages [23–27], and frozen meat as well [28–30]. Yeasts also a considerable component of the mycoflora of minced meat and basterma [21] as well as fermented sausages [27, 31].

Some other fungi were isolated in high frequency from samples of company B, *Alternaria* (*A. alternata*), *Cladosporium* (*C. sphaerospermum*) and *Rhizopus* (*R. stolonifer*). Another species of *Alternaria*, *A. tenuissima*, was rarely encountered from company A

*Table 1.* Fungi associated with 50 luncheon meat samples from the two producing companies in Egypt*

| Taxa | Company A | | | | Company B | | | |
|---|---|---|---|---|---|---|---|---|
| | NI | %I | %F | O | NI | %I | %F | O |
| *Acremonium strictum* W. Gams | 2 | 0.32 | 8 | R | 4 | 0.59 | 8 | R |
| *Actinomucor elegans* (Eidam) C.R. Ben & Hesseltine | 8 | 1.29 | 4 | R | | | | |
| *Alternaria* | 31 | 4.98 | 60 | H | 31 | 4.60 | 44 | M |
| *A. alternata* (Fries) Keissler | 27 | 4.34 | 52 | H | 31 | 4.60 | 44 | M |
| *A. tenuissima* (Kunze) Wiltshire | 4 | 0.64 | 8 | R | | | | |
| *Aspergillus* | 134 | 21.54 | 100 | H | 177 | 26.26 | 100 | H |
| *A. alutaceus* Berk. & Curtis | 2 | 0.32 | 8 | R | 1 | 0.15 | 4 | R |
| *A. flavus* Link | 64 | 10.29 | 84 | H | 71 | 10.53 | 84 | H |
| *A. fumigatus* Fres. | 4 | 0.64 | 12 | R | 8 | 1.19 | 20 | L |
| *A. melleus* Yukawa | | | | | 1 | 0.15 | 4 | R |
| *A. niger* van Tieghem | 61 | 9.81 | 88 | H | 89 | 13.21 | 92 | H |
| *A. oryzae* (Ahlb.) Cohn | 2 | 0.32 | 4 | R | | | | |
| *A. sydowii* (Bain. & Sart.) Thom & Church | | | | | 6 | 0.89 | 24 | L |
| *A. terreus* Thom | 1 | 0.16 | 4 | R | 1 | 0.15 | 4 | R |
| *Candida parapsilosis* (Ashford) Langeron & Talice | 11 | 1.77 | 4 | R | | | | |
| *Cladosporium* | 27 | 4.34 | 52 | H | 43 | 6.38 | 48 | M |
| *C. cladosporioides* (Fres.) de Vries | | | | | 5 | 0.74 | 4 | R |
| *C. sphaerospermum* Penz. | 27 | 4.34 | 52 | H | 38 | 5.64 | 44 | M |
| *Cochliobolus* | 6 | 0.97 | 24 | L | 1 | 0.15 | 4 | R |
| *C. lunatus* Nelson & Haasis | 1 | 0.16 | 4 | R | 1 | 0.15 | 4 | R |
| *C spicifer* Nelson | 5 | 0.80 | 20 | L | | | | |
| *Colletotrichum dematium* (Pers.) Grove | | | | | 1 | 0.15 | 4 | R |
| *Curvularia ovoidea* ( Hiroe & Watan.) Muntanola | 2 | 0.32 | 4 | R | | | | |
| *Emericella* | 1 | 0.16 | 4 | R | 4 | 0.59 | 12 | R |
| *E. nidulans* (Eidam) Vuillemin | 1 | 0.16 | 4 | R | 3 | 0.45 | 12 | R |
| *E. quadrilineata* (Thom & Raper) C.R. Benjamin | | | | | 1 | 0.15 | 4 | R |
| *Epicoccum nigrum* Link | 2 | 0.32 | 8 | R | 5 | 0.74 | 20 | L |
| *Fennellia flavipes* Willey & Simmons | 2 | 0.32 | 8 | R | | | | |
| *Geotrichum candidum* Link | | | | | 2 | 0.30 | 4 | R |
| *Gibberella fujikuroi* (Sawada) Ito | | | | | 2 | 0.30 | 8 | R |
| *Mucor* | 45 | 7.24 | 40 | M | 53 | 7.86 | 40 | M |
| *M. circinelloides* van Tieghem | 45 | 7.24 | 40 | M | 46 | 6.83 | 24 | L |
| *M. racemosus* Fres. | | | | | 7 | 1.04 | 24 | L |
| *Mycosphaerella tassiana* (De Not) Johanson | 16 | 2.57 | 24 | L | 27 | 4.01 | 28 | M |
| *Nectria haematococca* Berk. & Brown | 1 | 0.16 | 4 | R | 1 | 0.15 | 4 | R |
| *Paecilomyces variotii* Bainier | 2 | 0.32 | 4 | R | | | | |
| *Penicillium* | 116 | 18.65 | 96 | H | 85 | 12.61 | 88 | H |
| *P. aurantiogriseum* Dierckx | 21 | 3.38 | 48 | M | 11 | 1.63 | 28 | M |
| *P. chrysogenum* Thom | 76 | 12.22 | 84 | H | 48 | 7.12 | 76 | H |
| *P. hirsutum* Dierckx | 3 | 0.48 | 12 | R | 1 | 0.15 | 4 | R |
| *P. janczewskii* Zaleski | 1 | 0.16 | 4 | R | | | | |
| *P. oxalicum* Currie & Thom | 11 | 1.77 | 24 | L | 10 | 1.48 | 32 | M |
| *P. solitum* Westl. | 1 | 0.16 | 4 | R | | | | |
| *P. variabile* Sopp | 1 | 0.16 | 4 | R | | | | |
| *P. viridicatum* Westl. | 2 | 0.32 | 8 | R | 15 | 2.23 | 4 | R |
| *Pleospora tarda* E. Simmons | | | | | 10 | 1.48 | 16 | L |
| *Rhizopus stolonifer* (Ehren.) Lind | 57 | 9.1 | 56 | H | 34 | 5.05 | 28 | M |
| *Rhodotorulua mucilaginosa* (A. Jorg.) F.C. Harrison | 4 | 0.64 | 4 | R | 4 | 0.59 | 4 | R |
| *Syncephalastrum racemosum* (Cohn) Schroeter | 6 | 0.97 | 8 | R | 4 | 0.59 | 4 | R |

*Table 1.* Continued

| Taxa | Company A | | | | Company B | | | |
|---|---|---|---|---|---|---|---|---|
| | NI | %I | %F | O | NI | %I | %F | O |
| *Trichoderma harzianum* Rifai | | | | | 5 | 0.74 | 8 | R |
| *Trichosporon cutaneum* (de Beurm., Goug.& Vauch.) Ota | 2 | 0.32 | 8 | R | 12 | 1.78 | 24 | L |
| *Ulocladium chartarum* (Preuss) E. Simmons | 1 | 0.16 | 4 | R | | | | |
| Yeasts | 145 | 23.31 | 84 | H | 169 | 25.08 | 88 | H |
| *Zygorrhynchus heterogamous* (Vuill.) Vuill. | 1 | 0.16 | 4 | R | | | | |
| Total isolates | 622 | 100 | 100 | | 674 | 100 | 100 | |
| Total number of genera (27) | 22 | | | | 20 | | | |
| Total number of species (46) | 36 | | | | 33 | | | |

*NI = Number of isolates (calculated per 375 segments).
%I = Percentage isolates (calculated per total fungal isolates of 25 samples).
%F = Percentage frequency (calculated per total luncheon samples, 25 from each company).
O = Occurrence: H = high 50–100% of the cases, M = moderate 25–49% of the cases, L = low, 13–24% of the cases, R = rare, 1–12% of the cases.

samples only. Other *Cladosporium* species (*C. cladosporioides*) was also rarely encountered but only from company B samples. Out of the three genera mentioned above, only *Cladosporium* was obtained and less frequent from luncheon meat [21] and from other meat products such as sausage, beefburger, basterma, minced meat and frozen meat [21, 22]. However, *Alternaria* (*A. alternata*) has been recorded from cold stored and frozen meat [30, 32, 33]. *R. stolonifer* also was reported previously from meat products [30, 34].

Two other genera were encountered in moderate occurrence from samples of company B; *Mucor* with *M. circinelloides* being the most frequent species and *Mycosphaerella* with *M. tassiana* the most common species. *Mucor* species were moderately isolated and *Mycosphaerella* species in low frequency from samples of company A. Only *Mucor* was isolated less frequently from luncheon meat [21, 22], sausage, beefburger, minced meat, frozen meat [22, 23], as well as from cold stored meat [28, 33]. *Mucor circinelloides* has been reported from meat [34]. Also, *M. racemosus* has been found contaminating frozen and processed meats [30, 35] and beef carcasses [36].

The remainder of the fungus species were infrequently isolated either from samples of company A (*Actinomucor elegans, Candida parapsilosis, Cochliobolus spicifer, Curvularia ovoidea, Fennellia flavipes, Paecilomyces variotii, Ulocladium chartarum, Zygorrhynchus heterogamous*); or company B (*Colletotrichum dematium, Emericella quadrilineata, Geotrichum candidum, Gibberella fujikuroi, Pleospora tarda, Trichoderma harzianum*) or from samples of both luncheon meat-producing companies (*Acremonium strictum, Cochilobolus lunatus, Emericella nidulans, Epicoccum nigrum, Nectria haematococca, Rhodotorula mucilaginosa, Syncephalastrum racemosum* and *Trichosporon cutaneum*). Of these fungi, *Geotrichum candidum* and *Trichosporon* had been reported from luncheon meat; however *Rhodotorula* was isolated from other meat products (minced meat and basterma) [21]. Most of these fungi were isolated from other meat products, sausage [23], frozen meat [28–30] and from beef carcases as well [33, 36–39].

*Aflatoxin residues in luncheon meat samples*

Aflatoxin $B_2$, $G_2$, $M_1$ and $M_2$ were not detected in any of the 50 luncheon meat samples analyzed. However, only 7 luncheon meat samples out of 50 tested, 4 from company A and 3 from company B, were found to be contaminated by aflatoxin $B_1$, and only one of the three aflatoxin $B_1$ – contaminated samples from company B was also contaminated with aflatoxin $G_1$ (Table 3). The highest detectable levels were 11.1 ppb and 3.2 ppb for aflatoxins $B_1$ and $G_1$, respectively. Similar results were obtained by Roushdy et al. [22] who found that only 10%, 2 samples out of 20 analyzed, of luncheon meat samples were contaminated by aflatoxin with a mean concentration of 0.41 ppm. On the other hand, aflatoxins have been reported from fresh meat, frozen meat or other meat products (minced, fresh sausage, beefburger) [22].

Aflatoxins are produced in nature only by *Aspergillus flavus, A parasiticus* and *A nomius* [6, 40, 41]. In this study, luncheon meat samples were found

*Table 2.* Count [M ± SD(M*n*–M*x*)] and percentage of the most commonly encountered fungi from the contaminated segment of luncheon meat (%S) of the two companies*

| | Company A | | Company B | |
|---|---|---|---|---|
| | [M ± SD($M_n$–$M_x$)] | %S | [M ± SD($M_n$–$M_x$)] | %S |
| Total | [24.88 ± 6.75 (11–47)] | | [26.96 ± 7.98 (18–51)] | |
| Yeasts | [5.8 ± 4.28 (0–13)] | 38.7 | [6.76 ± 3.82 (0–15)] | 45.1 |
| *Aspergillus* | [5.36 ± 6.26 (0-30)] | 35.7 | [7.08 ± 5.74 (0–27)] | 47.2 |
| *A. niger* | [2.44 ± 3.07 (0–14)] | 16.3 | [3.56 ± 2.97 (0–12)] | 23.7 |
| *A. flavus* | [2.56 ± 3.11 (0–14)] | 17.1 | [2.84 ± 3.35 (0–15)] | 18.9 |
| *Penicillium* | [4.64 ± 3.84 (0–16)] | 30.9 | [3.4 ± 3.65 (0–17)] | 22.7 |
| *P. chrysogenum* | [3.04 ± 3.13 (0–15)] | 20.3 | [1.92 ± 1.66 (0–5)] | 12.8 |
| *P. aurantiogriseum* | [0.84 ± 1.07 (0–3)] | 5.6 | [0.44 ± 0.92 (0–4)] | 2.9 |
| *P. oxalicum* | [0.44 ± 0.96 (0–4)] | 2.9 | [0.4 ± 0.71 (0–3)] | 2.7 |
| *Rhizopus stolonifer* | [2.28 ± 2.56 (0–9)] | 15.2 | [1.36 ± 2.50 (0–8)] | 9.1 |
| *Mucor* | [1.8 ± 3.54 (0–14)] | 12 | [2.12 ± 3.75 (0–13)] | 14.1 |
| *M. circinelloides* | [1.8 ± 3.54 (0–14)] | 12 | [1.84 ± 3.85 (0–13)] | 12.3 |
| *Cladosporium* | [1.08 ± 1.26 (0–4)] | 7.2 | [1.72 ± 2.37 (0–8)] | 11.5 |
| *C. sphaerospermum* | [1.08 ± 1.26 (0–4)] | 7.2 | [1.52 ± 2.29 (0–8)] | 10.1 |
| *Alternaria* | [1.24 ± 1.54 (0–5)] | 8.3 | [1.24 ± 1.94 (0–6)] | 8.3 |
| *A. alternata* | [1.08 ± 1.47 (0–5)] | 7.2 | [1.24 ± 1.94 (0–6)] | 8.3 |
| *Mycosphaerella tassiana* | [0.64 ± 1.29 (0–5)] | 4.3 | [1.08 ± 2.34 (0–9)] | 7.2 |

*[M ± SD ($M_n$–$M_x$)] = M, mean total isolates out of 25 samples.
SD, Standard deviation.
$M_n$, minimum number of isolates arising from 15 segments of one of the 25 samples analyzed.
$M_x$, maximum number of isolates arising from 15 segments of one of the 25 samples analyzed.
%S: Calculated per total number of segments analyzed (375 from each company).

to be highly contaminated only by *A. flavus* of the aflatoxigenic species. It was isolated from 21 out of 25 luncheon samples examined from each company and accounted for approximately 10% of the total fungal isolates. Some luncheon meat samples contained higher numbers of *A. flavus* isolates than others and these samples were found to be aflatoxin free. These results agree with those obtained by Bullerman [42] and Zohri et al. [43] who reported that the presence of toxigenic moulds in a food product did not automatically mean the presence of mycotoxins, though it indicated the potential for mycotoxin contamination.

Since aflatoxin $B_1$ is heat stable [44], it is not affected by heating during luncheon meat processing. The possibility exists that contamination of luncheon meat by aflatoxin could have originated either from the animal tissues previously fed on aflatoxin-contaminated feed or by use of aflatoxin – contaminated ingredient, e.g. cereals. Early studies by Allcroft and Carnagham [45] and Keyl et al. [46] on aflatoxin residues in meat tissues of animals fed contaminated feed suggested that no significant buildup of aflatoxins in animal tissues occurred. However, other workers reported that significant quantities of the aflatoxins have been detected in beef cattle [47] fed on aflatoxin contaminated feeds. Feng and Tang [48] found that maize, maize bran, groundnut cakes, and any mixed feed containing maize and groundnut cakes were seriously contaminated with aflatoxins.

In this study, luncheon meat samples from the two main luncheon-producing companies were demonstrated to be contaminated by a wide variety of spoilage fungi and yeasts. Of these fungi, some are known to be mycotoxin producers; *A. alutaceus*, *A. flavus*, *A. sydowii*, *Emericella nidulans*, *Gibberella fujikuroi*, *P. aurantiogriseum*, *P. viridicatum*. Luncheon meat samples were highly contaminated by aflatoxigenic species *A. flavus*, and by aflatoxins as well. Such contamination in meat products is a matter of considerable concern as ingestion of low levels of mycotoxins over extended periods constitutes a public health hazard. Contamination probably originated from other additives than animal tissues or during processing, transport and/or storage. Therefore, food additives should be analyzed for mycoflora and mycotoxins especially aflatoxins, before these additives are used in food manufacturing. Also, strict hygienic measures

*Table 3.* Total number of isolates (TI), their percentages (%I) and percentage frequency (%F) of the total fungal propagules and of most frequently encountered species and aflatoxin residues from 50 luncheon meat samples of the two companies A and B, 25 samples from each*

| Sample | Total isolates (TI) | | *Alternaria alternata* | | *Aspergillus flavus* | | *Aspergillus niger* | | *Cladosporium sphaerospermum* | | *Mucor circinelloides* | | *Penicillium aurantiogriseum* | | *Penicillium chrysogenum* | | *Rhizopus stolonifer* | | Yeasts | | *Aflatoxins*, ppb | |
|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|
| No. | A | B | A | B | A | B | A | B | A | B | A | B | A | B | A | B | A | B | A | B | A | B |
| 1 | 25 | 30 | 3 | 1 | 2 | 6 | 2 | 3 | 3 | 4 | | | | | | 2 | 5 | | | 6 | 1.3B1 | 11.1B1, 3.2G1 |
| 2 | 47 | 25 | 5 | 5 | 14 | 3 | 14 | 2 | | | | | 3 | | 5 | 1 | 3 | 4 | | 3 | | |
| 3 | 27 | 32 | | 6 | 3 | | 1 | 3 | | 2 | | | 1 | | 15 | 1 | 1 | 5 | 6 | 10 | | |
| 4 | 34 | 27 | 1 | 2 | 6 | 9 | 3 | 8 | 3 | | | | 1 | | 2 | | 5 | | 8 | 8 | | |
| 5 | 32 | 51 | | 5 | 8 | 15 | 6 | 12 | | | | | | 1 | 3 | 5 | 1 | | | 5 | | |
| 6 | 24 | 27 | 1 | | 1 | | 1 | 2 | 2 | 4 | | | | | | 1 | | | 8 | 9 | | |
| 7 | 11 | 21 | | 1 | | 1 | 1 | 2 | 1 | 1 | | | | | 1 | 3 | | 8 | 7 | | | |
| 8 | 20 | 27 | 1 | | 1 | 2 | 2 | 2 | 1 | 6 | | | | | | | | | 10 | 7 | | |
| 9 | 22 | 33 | 1 | 3 | 2 | 2 | 1 | 2 | | | | | | | 1 | 2 | | 4 | 13 | 8 | | |
| 10 | 25 | 27 | | 1 | 1 | | 2 | 3 | 2 | 4 | 1 | | | | 2 | 1 | | | 9 | 13 | | |
| 11 | 25 | 30 | 2 | | 1 | 3 | 5 | | 4 | 1 | | | | | 1 | | 3 | 5 | 6 | 15 | | 2.5B1 |
| 12 | 20 | 23 | | 1 | 1 | 1 | 1 | 8 | 3 | | | 4 | | | 1 | | | 7 | 13 | 1 | 1.6B1 | |
| 13 | 21 | 32 | 1 | 1 | 3 | | 2 | | | 5 | | | | | 3 | 2 | | | 12 | 5 | | |
| 14 | 25 | 46 | 1 | 5 | | 6 | 1 | 10 | 2 | 8 | 10 | | | 4 | 3 | 3 | 4 | 1 | 2 | 6 | | |
| 15 | 17 | 22 | | | | 1 | | 1 | | 2 | 14 | 13 | 1 | | 1 | 2 | | | 1 | | | |
| 16 | 24 | 28 | 1 | | 2 | 1 | 1 | 4 | | 1 | 1 | 6 | 2 | 2 | 4 | 3 | 9 | | 2 | 9 | | |
| 17 | 35 | 23 | 4 | | 4 | 3 | 1 | 3 | 2 | | 2 | 13 | | | 5 | 4 | 5 | | 11 | | | |
| 18 | 24 | 18 | 4 | | 4 | 1 | 8 | 1 | | | | | 2 | 1 | 2 | 1 | | | | 10 | | |
| 19 | 22 | 19 | | | 5 | 4 | 3 | 4 | | | | | 1 | | | | 5 | | 6 | 8 | | |
| 20 | 25 | 20 | | | 1 | 1 | 1 | 4 | 1 | | | | 1 | | 2 | 3 | 2 | | 9 | 6 | 2.3B1 | 2.0B1 |
| 21 | 25 | 28 | 2 | | 1 | 3 | | 3 | | | 4 | 5 | 3 | 1 | 4 | 5 | 5 | | 4 | 8 | 0.5B1 | |
| 22 | 23 | 18 | | | 1 | 1 | | 1 | 1 | | 3 | | 2 | 1 | 6 | 1 | | | 7 | 10 | | |
| 23 | 25 | 19 | | | 1 | 4 | 1 | 4 | 2 | | 2 | | 3 | | 5 | | 5 | | 2 | 8 | | |
| 24 | 20 | 20 | | | | 1 | 3 | 4 | | | 1 | | 1 | | 5 | 3 | 4 | | 2 | 6 | | |
| 25 | 24 | 28 | | | 2 | 3 | 1 | 3 | | | 7 | 5 | | 1 | 5 | 5 | | | 7 | 8 | | |
| TI | 622 | 674 | 27 | 31 | 64 | 71 | 61 | 89 | 27 | 38 | 45 | 46 | 21 | 11 | 76 | 48 | 57 | 34 | 145 | 169 | | |
| %I | 100 | 100 | 4.3 | 4.6 | 10.3 | 10.5 | 9.8 | 13.2 | 4.3 | 5.6 | 7.2 | 6.8 | 3.4 | 1.6 | 12.2 | 7.1 | 9.2 | 5.1 | 23.3 | 25.1 | | |
| %F | 100 | 100 | 52 | 44 | 84 | 84 | 88 | 92 | 52 | 44 | 40 | 24 | 48 | 28 | 84 | 76 | 56 | 28 | 84 | 88 | | |

*The figures are calculated per 15 segments taken from each luncheon meat sample except the figures for aflatoxins are calculated as ppb.

and regulations should be followed during processing. packaging, transportation, storage and/or handling of such foods.

## References


1. Mossel DAA. Microbiology of food. 3rd ed. The University of Ulterecht, The Netherlands, 1982.
2. Diener UL, Davies ND, Salmon WD, Prickett CO. Toxin-producing *Aspergillus* isolated from domestic peanuts. Science 1963; 142: 1491–1492.
3. Wogan GN, Paglialunga S, Newberue PN. Carcinogenic effect of low dietary levels of aflatoxin $B_1$ in rats. Food Cosmet Toxicol 1974; 12: 681–685.
4. Chu FS. Mode of action of mycotoxins and related compounds. Adv Appl Microbiol 1977; 40: 352–357.
5. Hsieh DPH. The role of aflatoxins in human cancer. In: Steyn PS, Viggar R, eds. Mycotoxins and phytotoxins. Amsterdam: Elsevier Science 1986: 447–456.
6. Pitt JI, Hocking AD. Fungi and food spoilage. 2nd ed. Blackie Academic & Professional, London, U.K., 1997, 593 pp.
7. Ranken MD. Meat and meat products. In: Food Industries Manual, 21st ed. Chapter 1, 1984, 18 pp, Leonard Hill, USA.
8. King AD, Hocking AD, Pitt JI. Dichloran-rose bengal medium for enumeration and isolation of molds from foods. Appl Environ Microbiol 1979; 37: 959–964.
9. Raper KB, Fennell DI. The genus *Aspergillus*. Baltimore, Williams and Wilkins, 1965, 686 pp.
10. Ellis MB. Dematiaceous Hyphomycetes. Kew Surrey: Commonwealth Mycological Institute 1971: 608 pp.
11. Ellis MB. More Dematiaceous Hyphomycetes. Kew, Surrey: Commonwealth Mycological Institute 1976: 507 pp.
12. Booth C. *Fusarium*: Laboratory Guide to the Identification of the Major Species. Kew, Surrey: Commonwealth Mycological Institute 1977; 58 pp.
13. Pitt JI. The genus *Penicillium* and its Teleomorphic States *Eupenicillium* and *Talaromyces*. London: Academic Press, 1979, 634 pp.
14. Domsch KH, Gams W, Anderson T-H. Compendium of Soil Fungi. London: Academic Press 1980; 859 pp.
15. Sivanesan A. Graminicolous species of *Bipolaris*, *Curvularia*, *Drechslera*, *Exserohilum* and their teleomorphs. Mycological Papers 1987; 158: 1–261, C.A.B. International Mycological Institute, Ferry Lane, Kew, Surrey, UK.
16. Samson RA, van Reenen-Hoekstra ES. Introduction to foodborne fungi. Centraalbureau voor Schimmelcultures, Baarn, The Netherlands, 1988, 299 pp.
17. Kozakiewicz Z. *Aspergillus* Species on Stored Products. Mycological Papers 1989; 161: 1–188, C.A.B. International Mycological Institute, Ferry Lane, Kew, Surrey, UK.
18. Moubasher AH. Soil fungi in Qater and other Arab countries. The Scientific and Applied Research Centre, University of Qater, Doha, Qatar, 1993, 566 pp.
19. Association of Official Analytical Chemists. Official Methods of Analysis. 13th ed, Benjamin, Franklin stat, Washington, DC 1980.
20. Kalton G. Introduction to statistical ideas from social scientist. 2nd ed. London: Academic Press, 1967.
21. Abdel-Rahman HA, Yossef H, Hefnawey Y. Mycological quality of meat products in Egypt. Assiut Vet Med J 1984; 12(24): 153–159.
22. Roushdy S, Ibrahim A, Aldanaf N, Hammad H, Moustafa R. Mycotoxin residues in meat and meat products. Vet Med J, Giza 1996; 44(2): 181–187.
23. Lotfi A, Abd El-Rahman HA, Hefnawy Y, Youssef H. Studies on the mycological status of sausage in Upper Egypt. Fleischwirtschaft 1983; 63(4): 595–596.
24. Grazia L, Romano P, Bagni A, Roggiani D, Guglielmi G. The role of moulds in the ripening process of salami. Food Microbiol 1986; 3: 19–25.
25. Mutti P, Previdi MP, Quintavalla S, Spotti E. Toxigenicity of mould strains isolated from salami as a function of culture medium. Ind Conserve 1988; 63: 142–145.
26. Kaur H, Joshi DV, Kwatra MS, Jand SK. Preliminary studies on mycoflora of pig sausages. Ind J Comp Microbiol Immunol Infect Dis 1992; 13: 31–33.
27. Andersen SJ. Compositional changes in surface mycoflora during ripening of naturally fermented sausages. J Food Prot 1995; 58: 426–429.
28. Abdel-Rahman H, Darwish A, Hamdy M. Mould affections of a meat cold store. Assiut Vet Med J 1985; 14(27): 131–134.
29. Mansour NK, Yassien NA, Darwish AM, EI-Sherief AM. Psychrotrophic spoilage moulds in imported frozen beef cuts. Vet Med J, Giza 1991; 39: 209–219.
30. Nassar A, Ismail MA. Psychrotrophic and mesophilic fungi isolated from imported frozen lean meat in Egypt. J Food Safety 1994; 14: 289–295.
31. Filtenborg O, Frisvad JC, Thrane U. Moulds in food spoilage. Int J Food Microbiol 1996; 33: 85–102
32. Inagaki N. On some fungi isolated from foods I. Trans Mycol Soc Japan 1962; 4: 1–5.
33. Refai M, Loot A. Studies of mould contaminations of meat in slaughter houses, butcher's shops and in cold stores. Mykosen 1969; 12(10): 621–624.
34. Hadlok R, Schipper MAA. Schimmelpilze und Fleisch: Reihe Mucorales. Fleischwirtschaft 1974; 54: 1796–1800.
35. Aziz NH, Youssef YA. Occurrence of aflatoxins and aflatoxin producing moulds in fresh and processed meat in Egypt. Food Addit Contam 1991; 8(3): 321–331.
36. Ismail MA, Abou Elala A-H, Nassar A, Michail DG. Fungal contamination of beef carcasses and the environment in a slaughterhouse. Food Microbiol 1995; 12: 441–445.
37. Yassein N, Mansour N, Eldaly E, Darwish A. Contamination of slaughtered camels, cattle and their surroundings with moulds in urban abattoir. Alex J Vet Sci 1989; 5(2): 185–193.
38. Mansour N, Hamdy M, Yassien N, Refai M. Dematiaceous hyphomycetes in slaughtered camels, cattle and surroundings at Cairo abattoir. Assiut Vet Med J 1990; 24(47): 145–152.
39. Nassar A, Ismail MA, Abou Elala A-H. The role of benzoic acid as a fungal decontaminant of beef carcases. Fleischwirtschaft 1995; 75(10): 1218–1220.
40. Kurtzman CP, Horn BW, Hesseltine CW. *Aspergillus nomius*, a new aflatoxin-producing species related to *Aspergillus flavus* and *Aspergillus tamarii*. Antonie van Leeuwenhoek 1986; 53: 147–158.
41. Wilson DM, Payne GA. Factors affecting *A. flavus* group infection and aflatoxin contamination of crops. Academic Press, New York, 1994.
42. Bullerman LB. Mycotoxins and food safety. Food Technol 1986; 40: 59–66.
43. Zohri AA, Abdel-Sater MA, Ismail MA. Incidence of aflatoxins and mould flora in corn snacks. J Food Sci Technol 1995; 32(4): 289–294.
44. Roegner FR. FAD Looks at aflatoxin. 38th Ann Technol Conf, Grain Elevtors Proc Supl Assn, Chicago, 1967.

45. Allcroft R, Carnagham RBA. Groundnut toxicity: an examination for toxin in human food products from animals fed toxic groundnut meal. Vet Rec 1963; 75: 259–263.
46. Keyl AC, Booth AN, Nasri MS, Gumbmann MR, Gagne WE. Chronic effects of aflatoxin in farm animal feeding studies. In: Harzberg M, ed. Proceedings 1st U.S. Japan Conf. on Toxic Microorganisms, Honolulu. UNJNR joint panels and U.S. Department of interior, Washington, DC 1970, pp. 72–75.
47. Purchase IFH. The control of aflatoxin residues in food of animal origin. Pure Appl Chem 1973; 35: 283–288.
48. Feng YC, Tang JR. Survey of aflatoxin contamination of feeds in Guangxi zhuang Autonomous Region, China. Chin J Vet Med 1990; 16(6): 16–18.

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