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Biogenic Amines as A Quality Marker in Beef and Chicken Products

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MANY TYPES of meat and its products contain biogenic amines (BAs), which are significant indicators of the stability and quality of the product, in addition to their effects on human health. This study collected 200 samples (25 of each minced beef, beef sausage, beef burger, beef kofta, frozen chicken breast, frozen chicken thigh, chicken burger, and chilled chicken fillet) from Aswan City during 2021–2022. The samples were subjected to microbiological quality assessment. 80 samples (10 of each) of the previously examined specimens were investigated by the HPLC technique for the investigation of five biogenic amines, including tryptamine, putrescine, cadaverine, histamine, and tyramine. The results revealed that the total aerobic count was higher in minced beef and beef kofta. Beef sausage and minced meat had the greatest Enterobacteria count. Meanwhile, chilled chicken fillets and chicken burgers had the lowest count. Concerning the mean Pseudomonads count, it was higher in beef sausage samples. Regarding the mean value of Lactic acid bacteria, counts were higher in frozen chicken thighs, frozen chicken breast, minced beef, and chilled chicken fillet. The beef kofta, minced beef, and beef sausage samples had the highest mold count. Likewise, the difference between the samples that were analyzed was statistically significant at ($p<0.05$). Additionally, there were major variations in biogenic amine content within and between product classes, some of which were not matched with Egyptian standards. The current study concluded that there was a positive relationship between microbial growth and the formation of biogenic amines.

Keywords: *Meat products, Biogenic amines***,** *Histamine***,** *HPLC.*

Introduction

The meat industry is now monitoring the product's quality and freshness to ensure that it meets consumer expectations due to the rising demand for meat processing. Additionally, meat and poultry products are often consumed because they contain minerals, vitamins, and proteins essential to human health [1]. Because meat and its products are nutritious foods, they should be accurately stored, prepared, packaged, and dispersed to prevent the development of microorganisms [2]. Meat provides a nutrient-rich environment for bacteria to develop and articulate several metabolic processes [3]. Meat quality or freshness is primarily monitored by the relationship between microbial growth and chemical alterations throughout storage [4]. Biogenic compounds (BAs), volatile amines, provide significant freshness indicators for meat. Nitrogenous organic bases are created when amino acids are decarboxylated or when aldehydes and ketones are transaminated in food. Microorganisms from particular genera, including *Clostridium*, *Bacillus*, *Pseudomonas*, *Photobacterium*, and the *Enterobacteriaceae* family (*Escherichia coli*, *Citrobacter*, *Shigella, Salmonella, Klebsiella*, and *Proteus*), are crucial for the formation of biogenic amines [5]. Putrescine, tyramine, cadaverine, and histamine are the biogenic amines utmost frequently established in meat and its products. Spermidine and

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spermine are the only amines in detectable amounts of fresh meat [6]. The probability of employing BAs as markers of food quality and their potential toxicity are the two factors that generate interest in the research of BAs presence in food. BAs may indicate microbial contamination and inadequate hygiene practices in handling or processing foodstuffs. Ordinarily, human intestinal amine oxidases can detoxify small amounts of Bas [7]. However, it has been proposed that the health risk escalates when the activity of amine oxidases is restricted or withdrawn by consuming significant quantities of BA [8]. The current study aimed to determine the concentration of biogenic amines in meat products sold in the Aswan governorate using high-performance liquid chromatography (HPLC).

Material and Methods

Samples

In 2021–2022, 200 samples of minced beef, beef sausage, beef burger, beef kofta, frozen chicken breast, frozen chicken thigh, chicken burger, and chilled chicken fillet were gathered in Aswan City. All the samples were packaged, labeled, and then delivered in an icebox container to the Aswan University, Faculty of Veterinary Medicine, Department of Food Hygiene, Meat Hygiene Lab for analysis.

Preparation of samples [9]

Aseptically transfer 10g of each sample into double-folded sterile plastic bags with sterile saline solution (0.9%), mix thoroughly, and allow to homogenize for 10 min (1/10 dilution). With a sterile pipette, one ml of the homogenate was transferred to another sterile tube with 9 ml of sterile saline (0.9%) for the preparation of ten-fold serial dilutions. The plates with between 30 and 300 colonies for each sample were totaled and documented as colony-forming units (CFU /g). The subsequent microbiological counts were performed:

Aerobic plate count [10]

One ml of each formerly made serial dilution was separately distributed into two identical Petri plates with the proper markings on Standard plate count agar (M091A, Hi-Media) and cultured for 48 hours at 37 °C in an aerobic environment.

Enterobacteria count [11]

In two identically marked Petri dishes with Violet Red Bile Glucose Agar (M581, Hi-Media) under anaerobe conditions at 37 °C for 24-48 h, one ml from each previously made serial dilution was single-handedly added. The large purple-haloed colonies were counted as CFU/g.

Pseudomonads count [12]

Pseudomonas agar base media (M085, Hi-Media) enhanced with glycerol were dispersed with one ml of each dilution and incubated aerobically at 25 °C for 48 h. Blue-green or brown pigmentation could be interpreted as presumptive evidence of *Pseudomonas aeruginosa*. Other species may produce brown or pink colonies on the medium that was counted.

Lactic acid bacteria (LAB) count [13]

In two correctly marked duplicated Petri dishes with deMan Rogosa Sharpe agar (MRS, M641I, Hi-Media) under anaerobic conditions at 37 °C for 24-48 h, one ml from each previously performed serial dilution was added separately. Large white colonies developed on or visible on MRS agar are lactobacilli.

Total fungal count [10]

One mL of the prepared dilution was added to two identical, sterile Petri dishes before gently blending with Sabouraud Dextrose Agar (SMH063, Hi-Media) and 150 ppm chloramphenicol to prevent bacterial development. The inoculation dishes were then tested for mold development and recorded as CFU/g after incubating for 5-7 days at 25 °C.

Determination of biogenic amine concentration by HPLC

As stated by the method suggested by Pinho *et al.,* [14] and Magwamba *et al.,* [15], five biogenic amines, including histamine (HIS), tyramine (TYR), tryptamine (TRY), putrescine (PUT), and cadaverine (CAD), had been detected in 80 tested meat product samples (10 of each).

Statistical Analysis

One-way Analysis of Variance (ANOVA) was achieved for significant variances between samples using the *GraphPad InStat* 3 for Windows program to calculate means and standard error.

Results

The results presented in Table 1 show that the total aerobic count (CFU/g) was higher in minced beef and beef kofta with a mean value of $2.9\times10^4\pm1.1$ and $2.92\times10^4\pm1.09$ while being nearly similar in the other products since chicken burgers had the lower count ($7.27\times10^3\pm1.3$). As well the data revealed that the *Enterobacteria* count was higher in beef sausage ($2.5\times10^4\pm1.5$) and minced meat ($1.44\times10^4\pm1.7$) than in other products. Concerning the *Pseudomonads* count, beef sausage and beef kofta were the highest, with mean values of $7.07\times10^4\pm3.3$ and $6.94\times10^4\pm2.5$. Meanwhile, the Lactic acid bacteria count in beef sausage samples was the highest ($1.2\times10^4\pm1.9$). Furthermore, beef kofta and minced beef had the highest total mold count, with mean values of $4.25\times10^2\pm1.5$ and $3.6\times10^2\pm0.47$.

Table 2 shows that the beef sausage, chicken burgers, and chilled chicken fillet had the greatest histamine concentration (mg/100g) with mean values of 99±5.7, 90.1±5.3, and 90±5.06, respectively, followed by beef burgers, frozen chicken breast, frozen chicken thighs, and beef kofta with mean values of 41.3±5.2, 13.6±1.3, 2.6±0.21, 1.7±0.16, and 0.5±0.08, respectively. The variance between the examined data was also statistically significant at ($p\leq0.05$).

Table 3 showed that the tyramine level (mg/100g) in the examined products (Table 3) had the greatest mean value in beef sausage (160±11.6 mg/100g), followed by beef burger (95±12.5 mg/100g), minced beef (69±5.1 mg/100g), chilled chicken fillet (60±7 mg/100g), beef kofta (42±6.1 mg/100g), frozen chicken breast (15.3±1.8 mg/100g), and frozen chicken thighs (8.6±0.7 mg/100g), while it failed to detect in chicken burger samples. The variance amongst the examined data was significant at ($p\leq0.05$).

Furthermore, the data in Table 4 indicated that the tryptamine concentration (mg/100g) was found only in frozen chicken breast and chilled chicken fillet, with prevalences of 6.7±0.8 mg/100g and 20±1.6 mg/100 g, with different significant values ($p\leq0.05$) among examined samples while failing to be detected in all other samples.

Table 5 pointed out that the beef kofta and frozen chicken thighs samples had the greatest concentration with mean values of 91±11 and 90±11.8, followed by chilled chicken fillet, chicken burgers, beef sausage, minced beef, and beef burger with mean values of 63±8.3, 60±10.7, 25±2.3, 4.3±0.7, and 2.3±0.1, respectively. Meanwhile, they fail to detect it in frozen chicken breast samples. Additionally, all the analyzed samples, except beef burgers, indicated a significant variance ($p\leq0.05$).

Concerning the data presented in Table 6, it shows that the cadaverine level (mg/100g) was detected with a high concentration in beef sausage, beef kofta, and beef burger with a mean of 320±22, 290±23, and 203±3.9 mg/100g, respectively. Meanwhile, frozen chicken thigh, chicken burger, and chilled chicken fillet with a mean of 133±14, 120±13, and 116±10.5 mg/100g, respectively. Moreover, minced beef and frozen chicken breast had the lowest concentration, with a mean of 72±8.4 and 23±2.5 mg/100g, respectively.

Discussion

Due to its importance for economic growth and public health, meat quality and protection are currently top priorities for the global food sector. The meat business is now monitoring its quality and freshness to meet consumer expectations due to the rising demand for meat processing. It is crucial to prevent meat deterioration from chemical compounds sustainably and healthfully. Total viable count (TVC) is a main quantitative microbiological indicator of production process cleanliness, safety assessment, and raw meat deterioration indication [16]. TVC in minced beef higher than 7 log CFU/g is unacceptable from a hygienic viewpoint and reveals lowly hygienic practices (Regulation (EC) 2073/2005 and 94/65/EEC) [17].

The results presented in Table 1 show that the differences in the count of beef and chicken burgers were significant at ($p\leq0.05$). However, there was no significant distinction between the other items. The higher microbial load in beef samples is probably due to the different contaminated raw materials and ingredients used and the processing methods. Closely similar findings were documented by Ahmed *et al.,* [18] and Hamed *et al.,* [19]. In comparison, higher results were reported by Younis *et al.,* [20]. Since particular members of the *Enterobacteriaceae* are pathogenic and can lead to critical illnesses and food poisoning, the group has epidemiological significance and interest. It is the most difficult bacterial pollutant to avoid when handling raw and processed beef foodstuffs [21]. Furthermore, the variations in the *Enterobacteria* count between minced beef, beef kofta, frozen chicken breast, and chilled chicken fillet were considered significant at ($p\leq0.05$). Moreover, Shaltout *et al.* [22] and Morshdy *et al.* [23] reported lower *Enterobacteriaceae* counts whereas Additionally, High decarboxylase activity is attributed to the family *Enterobacteriaceae*, mainly concerning the generation of histamine, cadaverine, and tyramine [24].

On the other hand, the occurrence of *Pseudomonas* spp. in foodstuffs is extremely significant since the organism is regarded as a bacterium harmful to humans and a marker of food quality [25]. The data achieved in the presented study showed no significant variance between the analyzed samples. The *Pseudomonas* count of breast and thigh meat studied by Ivanov *et al.* [26] was higher than the current study. Furthermore, lower results were achieved by Morshdy *et al.* [23] and Elbehiry *et al.* [27]. Due to their capability to increase in the absence of oxygen and their great resistance, even at low pH, lactic acid bacteria (LAB) become the predominant bacterial species once the growth of aerobic bacteria is reserved, causing the rotting of meat and its products [28]. No significant differences existed between the analyzed samples concerning the mean value of Lactic acid bacteria count. The same results were reported by Jasna *et al.* [29]. From another viewpoint, the fungi that cause mycosis, mycotoxicosis, and allergies are considered major public health risks due to their ability to contaminate meat products [30]. The data in the current study revealed that the difference between the analyzed samples was statistically significant at ($p<0.05$). This finding was higher than the results noted in a study by some authors [30-32].

Additionally, chemical metabolites formed through the microbial degradation of foodstuffs, such as biogenic amines, have been used as meat freshness markers [33]. Biogenic amines (BAs) are low molecular weight compounds with biological activity produced by the decarboxylation of amino acids or amination and transamination of aldehydes and ketones during the metabolic processes in living cells [34]. From the current results, Fig. 1 and Tables 2-6 revealed the acceptability of the examined products based on their levels of biogenic amines stipulated by the Egyptian Organization for Standardization "EOS" (2005). The results came in agreement with Ekici *et al.* [35], Li *et al.* [36] while Mahmoud *et al.* [37] recorded high results. Meanwhile, lower results than those of the current study were reported by Algahtani *et al.* [38] and Saewan *et al.* [39]. There were significant variants in biogenic amine content within and between product kinds. These variations rely on various factors, comprising the microflora's composition, chemical-physical variables, the processing method employed, the accessibility of precursors, the quantity of meat utilized, the sorts of substances used, and raw material quality [40]. The high quantity of BAs in the examined samples suggested improper handling, inadequate production hygiene standards, inferior raw materials, and high microbial pollution [41].

Conclusion

The current study found a correlation between microbial growth and the production of biogenic amines throughout the storage period, as well as significant variations in biogenic amine content within and between different product categories. Along with a wide range of biogenic amine levels, some still need to meet Egyptian regulations due to unclean handling, transport, processing, and storing practices and improper environmental circumstances.

Conflicts of interest

Regarding the research data and resources used for this work, the authors confirm that no interests conflict.

Ethical approve

No approval of research ethics committees was required to accomplish the aim of this study because survey work was conducted with commercial products.

Funding statements

Not applicable.

Contribution of authors

Design: Nady Kh. Elbarbary; Supervision: Mohamed Karmi, Mohamed A. Maky; Data Collection and Processing: Rawia A. Rabeie; Writing the Article: Asem M. Zakaria, Nady Kh. Elbarbary

TABLE 1. Statistical values of microbial counts of the examined samples (n= 25)

Examined product	Total aerobic count	*Enterobacteria* count	*Pseudomonads* count	Lactic acid bacteria	Total mold count
Minced beef	$2.9\times10^4\pm1.1^a$	$1.44\times10^4\pm1.7^a$	$3.14\times10^4\pm2^a$	$7.52\times10^3\pm2.7^a$	$3.6\times10^2\pm0.47^a$
Beef sausage	$1.23\times10^4\pm5.1^a$	$2.5\times10^4\pm1.5^b$	$7.07\times10^4\pm3.3^a$	$1.2\times10^4\pm1.9^b$	$3.42\times10^2\pm1.03^a$
Beef burger	$1.54\times10^4\pm5.3^b$	$5.4\times10^3\pm2.2^b$	$1.51\times10^4\pm6.9^a$	$1.08\times10^4\pm2.3^b$	$2.73\times10^2\pm2.2^b$
Beef kofta	$2.92\times10^4\pm1.09^a$	$4.08\times10^3\pm1^c$	$6.94\times10^4\pm2.5^a$	$1.19\times10^4\pm1.9^b$	$4.25\times10^2\pm1.5^c$
Frozen chicken breast	$1.9\times10^4\pm9.0^a$	$2.3\times10^3\pm0.4^c$	$1.4\times10^4\pm5.3^a$	$7.71\times10^3\pm3.1^c$	$2.07\times10^2\pm0.46^b$
Frozen chicken thigh	$1.03\times10^4\pm7.6^a$	$3.9\times10^3\pm3^c$	$4.7\times10^4\pm1.6^b$	$7.9\times10^3\pm2.6^a$	$2.73\times10^2\pm0.72^b$
Chicken burger	$7.27\times10^3\pm1.3^c$	$1.3\times10^3\pm0.5^c$	$1.64\times10^4\pm6.2^a$	$2.46\times10^3\pm1.5^a$	$2.33\times10^2\pm0.75^b$
Chilled chicken fillet	$1.14\times10^4\pm8.2^a$	$1.02\times10^3\pm0.20^c$	$2.8\times10^4\pm1.1^a$	$4.11\times10^3\pm3.1^a$	$1.72\times10^2\pm1.62^b$

Means with different superscripts at the same column are significantly different at $p\leq0.05$

TABLE 2. Histamine levels (mg/100g) in the examined products (n=10)

Product	Positive samples		Min	Max	Mean ± S.E.*
	No.	%			
Minced beef	10	100	7.74	18.3	13.6 ± 1.3^a
Beef sausage	10	100	75.3	123.54	99 ± 5.7^b
Beef burger	10	100	18.73	57.3	41.3 ± 5.2^c
Beef kofta	10	100	0.23	1.0	0.5 ± 0.08^{ad}
Frozen chicken breast	10	100	1.46	3.42	2.6 ± 0.21^a
Frozen chicken thigh	10	100	0.84	2.64	1.7 ± 0.16^a
Chicken burger	10	100	63.72	112.3	90.1 ± 5.3^{bd}
Chilled chicken fillet	10	100	72.3	121.4	90 ± 5.06^b

S.E.* = standard error of mean. $p < 0.0001$, considered extremely significant. Values in the same column with different superscript letters are not significantly different at $p\leq0.05$.

TABLE 3. Tyramine levels (mg/100g) in the examined products (n=10)

Product	Positive samples No.	Positive samples %	Min	Max	Mean± S.E.*
Minced beef	10	100	48.6	88.4	69±5.1[a]
Beef sausage	10	100	92.4	192.4	160±11.6[b]
Beef burger	10	100	25.3	145	95±12.5[a]
Beef kofta	8	80	16.45	66.4	42±6.1[ac]
Frozen chicken breast	7	70	9.6	26.3	15.3±1.8[c]
Frozen chicken thigh	5	50	6.8	26.3	8.6±0.7[c]
Chicken burger	0	0	0	0	0[c]
Chilled chicken fillet	10	100	18.3	82.4	60±7[ac]

S.E.* = standard error of mean. $p < 0.0001$, considered extremely significant. Values in the same column with different superscript letters are not significantly different at $p \leq 0.05$.

TABLE 4. Tryptamine levels (mg/100g) in the examined products (n=10)

Product	Positive samples No.	Positive samples %	Min	Max	Mean± S.E.*
Minced beef	0	0	0	0	0[a]
Beef sausage	0	0	0	0	0[a]
Beef burger	0	0	0	0	0[a]
Beef kofta	0	0	0	0	0[a]
Frozen chicken breast	5	50	4.73	11.3	6.7±0.8[b]
Frozen chicken thigh	0	0	0	0	0[a]
Chicken burger	0	0	0	0	0[a]
Chilled chicken fillet	6	60	9.54	29.3	20±1.6[c]

S.E.* = standard error of mean. $p < 0.0001$, considered extremely significant. Values in the same column with different superscript letters are not significantly different at $p \leq 0.05$

TABLE 5. Putrescine levels (mg/100g) in the examined products (n=10)

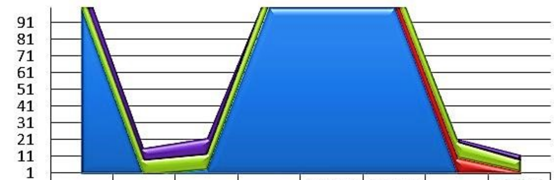
Product	Positive samples		Min	Max	Mean ± S.E.*
	No.	%			
Minced beef	6	60	2.1	8.4	4.3±0.7[a]
Beef sausage	6	60	14.3	33.4	25±2.3[ab]
Beef burger	4	40	0	7.3	2.3±0.1[b]
Beef kofta	10	100	25.3	122.43	91±11[c]
Frozen chicken breast	0	0	0	0	0[ab]
Frozen chicken thigh	10	100	36.2	132.4	90±11.8[c]
Chicken burger	10	100	18.64	86.3	60±10.7[bc]
Chilled chicken fillet	10	100	16.4	82.3	63±8.3[c]

S.E.* = standard error of mean. *p* value is < 0.0001, considered extremely significant. Values in the same column with different superscript letters are not significantly different at $p \leq 0.05$.

TABLE 6. Cadaverine levels (mg/100g) in the examined products (n=10)

Product	Positive samples		Min	Max	Mean± S.E.*
	No.	%			
Minced beef	10	100	27.4	98.4	72±8.4[a]
Beef sausage	10	100	222.5	420.3	320±22[b]
Beef burger	10	100	187	221	203±3.9[d]
Beef kofta	10	100	153.7	364.3	290±23[b]
Frozen chicken breast	10	100	11.4	33.6	23±2.5[a]
Frozen chicken thigh	10	100	53.8	194.3	133±14[ac]
Chicken burger	10	100	59.4	173.7	120±13[ac]
Chilled chicken fillet	10	100	66.3	165.3	116±10.5[ac]

S.E.* = standard error of mean. *p* value is < 0.0001, considered extremely significant. Values in the same column with different superscript letters are not significantly different at $p \leq 0.05$.



	Minced beef	Beef sausage	Beef burger	Beef kofta	Frozen chicken breast	Frozen chicken thigh	Chicken burger	Chilled chicken fillet
Cadaverine	0	0	0	0	4	0	0	0
Putrescine	10	7	10	0	10	0	2	4
Tryptamine	10	10	10	10	8	10	10	7
Tyramine	0	0	0	2	7	7	10	2
Histamine	100	0	3	100	100	100	0	0

Fig. 1. The acceptability of the examined products based on their levels of biogenic amines stipulated by the Egyptian Organization for Standardization "EOS" (2005)

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الأمينات الحيوية كعلامة جودة في منتجات لحوم البقر والدجاج

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تحتوي العديد من أنواع اللحوم ومنتجاتها على الأمينات الحيوية (BAs) ، وهي مؤشرات مهمة على جودة المنتج بالإضافة إلى تأثيرها على صحة الإنسان. في هذه الدراسة ، ، تم جمع ٢٠٠ عينة من منتجات اللحوم والدواجن لشركات مختلفة من محلات السوبر ماركت المحلية في مناطق مختلفة في مدينة أسوان خلال الفترة من٢٠٢٢ الى ٢٠٢٣ (بواقع ٢٥ عينة من اللحم المفروم، السجق البقري ، البرجر البقري، الكفتة البقري، صدور الدجاج المجمد، اوراك الدجاج المجمد، برجر الدجاج و شرائح الدجاج المبردة) لتحديد جودة هذه المنتجات عن طريق إجراء الفحص البكتريولوجي و تحديد مستوي التلوث في هذه العينات عن طريق العد البكتيري لها ثم تحليل ٨٠ عينة (١٠ من كل منتج) من العينات التي تم فحصها مسبقًا باستخدام جهاز الكروماتوغرافيا عالية الأداء (HPLC) لتحديد نسبة بعض الأمينات الحيوية بها مثل الهيستامين، التيرامين، التربتامين، بوتريسين و كادافيرين. أوضحت النتائج أن إجمالي العد الهوائي (CFU / g) كان أعلى في لحم البقر المفروم وكفتة اللحم البقري بمتوسط قيمة ٢,٩ × ١٠٤ ± ١,١ و ٢,٩٢ × ١٠٤ ± ١,٠٩. سجق اللحم البقري (٢,٥ × ١٠٤ ± ١,٥ CFU / جم) واللحوم المفرومة (١,٤٤ × ١٠٤ ± ١,٧ CFU / جم) كان لها أكبر عدد من البكتيريا المعوية بين العينات التي تم فحصها في الوقت نفسه كان فيليه الدجاج المبرد (١,٠٢ × ١٠٣ ± ٠,٢ CFU / جم) وبرجر الدجاج (١,٣ × ١٠٣ ± ٠,٥ CFU / جم) أقل عدد. فيما يتعلق بمتوسط عدد السيدمونس ، فقد كان أعلى في عينات السجق البقري بمتوسط قيمة ٧,٠٧ × ١٠٤ ± ٣,٣ ، يليه ٦,٩٤ × ١٠٤ ± ٢,٥ في كفتة اللحم البقري. فيما يتعلق بمتوسط قيمة بكتيريا حمض اللاكتيك لاوراك الدجاج المجمدة وصدور الدجاج المجمد ولحم البقر المفروم وفيليه الدجاج المبرد ، فقد كانت ٧,٩ × ١٠٣ ± ٢,٦ ، ٧,٧١ × ١٠٣ ± ٣,١ ، ٧,٥٢ × ١٠٣ ± ٢,٧ و ٤,١١ × ١٠٣ ± ٣,١ على التوالي. سجلت عينات الكفتة البقري واللحم البقري المفروم والسجق أعلى عدد من العفن بمتوسط ٤,٢٥ × ١٠٢ ± ١,٥ و ٣,٦ × ١٠٢ ± ٠,٤٧ و ٣,٤٢ × ١٠٢ ± ١,٠٣ على التوالي. وبالمثل كان الاختلاف بين العينات التي تم تحليلها ذا دلالة إحصائية عند ($p < 0.05$). بالإضافة إلى ذلك ، كانت هناك اختلافات كبيرة في انتاج محتوى الأمين الحيوي داخل وبين فئات المنتجات. وكذلك أصناف كبيرة من الأمينات الحيوية ، بعضها غير مطابق للمواصفات القياسية المصرية. خلصت الدراسة الحالية إلى وجود علاقة إيجابية بين النمو الميكروبي وتكوين الأمينات الحيوية.

الكلمات الدالة: منتجات اللحوم، الامينات الحيوية، الهستامين، HPLC