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ASSESSMENT OF MONOSODIUM GLUTAMATE (MSG), SENSORY, PHYSICO-CHEMICAL AND MICROBIOLOGICAL QUALITY IN SOME MEAT PRODUCTS

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ABSTRACT

This study aimed to assess the values of one of the harmful food additives used in food production, monosodium glutamate (MSG). A total of 60 random samples of some frozen meat products included beef burger, sausage, beef kofta and chicken nuggets (15 for each) collected from different supermarkets in Assiut City, Egypt. The samples were subjected to sensory evaluation, physico-chemical and microbiological quality. The findings revealed that the examined beef kofta samples have the lowest scores of sensory attributes, compared to beef burger and chicken nuggets samples, which recorded the highest scores. Concerning MSG, the results revealed levels were 1.415 mg/gm. in beef burger; 2.28 in sausage; 2.18 in beef kofta and 3.34 in chicken nuggets, respectively. Moreover, pH determined, and the mean values were 6.37 in beef burger; 6.22 in sausage; 6.45 in beef kofta and 6.27 in chicken nuggets, respectively. Also, the mean values for total volatile basic-nitrogen (TVB-N) (mg/100gm.) and thiobarbituric acid number (TBA) (mg MAD/kg) were 9.52 and 0.35 in beef burger; 12.13 and 0.27 in sausage; 8.87 and 0.4 in beef kofta and 11.11 and 0.23 in chicken nuggets, respectively, which within the permissible limits and all accepted according to the Egyptian standard specifications. Moreover, the bacteriological examination showed that mean values (cfu/g) of TBC and Total Y&M Count were $1.03x10^5±5.12x10^4$ and $1.33x10^4±7.12x10^3$ in beef burger; $1.43x10^5±6.63x10^4$ and $3.73x10^4±1.66x10^4$ in sausage; $6.75x10^4±3.01x10^4$ and $3.2x10^4±1.04x10^4$ in beef kofta and $5.33x10^4$ $±3.35x10^4$ and $1.98x10^4±9.67x10^3$ in chicken nuggets, respectively. Furthermore, *E.coli* 0157:H7 identified serologically in two of both beef burger and sausage were (13.33%) and in one of chicken nuggets was (6.67%). In conclusion, application strict hygiene practices along the meat production process is important to prevent low quality products and food-borne diseases.

Key words: Meat products, MSG, Physico-chemical examination, Microbiological examination, E. coli 0157:H7.

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INTRODUCTION

Meat products contain a variety of nutrients, including essential amino acids, trace elements, minerals, high-quality protein, vitamins and folic acid, as well as micronutrients, which are necessary for a wide range of metabolic processes and human healthy growth (Lau *et al.,* 2023; Stadnik, 2024). Meat products are popular because they solve the issue of lack fresh meat at high prices and provide quick and simple meat meals (Younes *et al.,* 2019). Because of susceptibility to infection from various spoilage bacteria and food-borne illnesses, preservatives are therefore an important component of the animal food industry, in order to prolong shelf-life, delay spoiling, and prevent food poisoning. But food consumers dislike industrial preservatives because of their harmful health impacts (Yu *et al.,* 2021). Also, food additives are widely used in the production of processed meat. Although meat products are raw materials with low levels of microbial contamination, they can become contaminated during the manufacturing process. Therefore, food additives extend the shelf-life and enhance texture, color, flavor, and taste (Aymerich *et al.,* 2008). The quality of food additives used in the production of meat products affect both the resulting products' quality and the public health, as higher levels than what is allowed could pose a risk to public health and/or cause technological issues (Pearson and Gillett 1996). On the other hand, they can decrease the oxidation of meat product ingredients (Nikmaram *et al.,* 2018). In the middle of the twentieth century, the risks of using food additives were assessed globally, as a joint committee (JECFA) of experts of the World Health Organization (WHO) of the United Nations and the Food and Agriculture Organization (FAO) was established in 1955 on food additives (Heinemeyer *et al.,* 2019). Despite the efforts to ensure the safe and proper use of food additives, these chemicals' harmful genetic effects target the kidneys and liver, increasing the risk to the immune system—the body's defensive mechanism against harmful microbes (Steven *et al.,* 2013; Dar *et al.,* 2017). One of these food additives is Monosodium Glutamate (MSG). It is known as E621 or Chinese salt. It is found naturally in foods such as meats, anchovies, mollusks, tomatoes, cheeses, shellfish, onions, carrots, potatoes, walnuts, and garlic. Also included in processed meats, frozen meals, soups, salad dressings, canned tuna, fast food, frozen dinners and potato chips (Henry-Unaeze, 2017). MSG gives a taste described in Japanese as "Umami taste" and it is one of the five basic tastes (together with sweetness, sourness, bitterness, and saltiness) and this makes it one of the most favorable food additives in the meat industry (Depoortere, 2014). From the Japanese, Umami can be translated as "pleasant savory taste". It induces salivation and a sensation of furriness on the tongue, stimulating the throat, the roof and the back of the mouth (Wijayasekara and Wansapala, 2017). MSG ingestion has a long history of adverse consequences in both animal and human research (Maluly *et al.,* 2017). Long-term consumption of MSG is reported to cause several health complications, such as metabolic diseases (diabetes, dyslipidemia, obesity), cardiovascular disease (hypertension and heart ailments), sleep, respiratory disorder and neuro-endocrine defects. Also has several negative consequences, including hepato-toxicity, renal toxicity and reproductive toxicity. In addition, Parkinson's disease, depression, brain injury, anxiety, addiction, Alzheimer's disease and epilepsy are all pathological disorders brought on by the neurotoxic effects of MSG (Kayode *et al.,* 2020). Also, the genetic material may be altered, allowing free radicals to damage the cell by destroying its nuclear component. So, MSG is directly responsible for genetic damage (Imam, 2019). Meat products are sensitive to biochemical and microbiological deterioration, because of their complex composition, which includes diverse types of saturated and unsaturated fatty acids, proteins, carbohydrates, vitamins, and colors that induce oxidation, especially during storage (Lorenzo *et al.,* 2017). Deterioration leads to formation of harmful chemicals, reduction in nutritional values, discoloration, texture degradation, off-odors and off-flavors (Min and Ahn, 2005). Changing the pH of meat has a substantial impact on its properties, including water-binding capacity, color, consistency, smell and taste, and stability during storage (Okuskhanova *et al.,* 2017). Furthermore, one of the most popular measurements for quality is Total Volatile Basic Nitrogen (TVB-N), that is linked to food spoilage, such as ammonia (produced by the deamination of amino acids and nucleotide catabolites), trimethylamine (produced by spoilage bacteria), and dimethylamine (produced by autolytic enzymes during frozen storage). Although TVB-N studies are quite simple to do, they often indicate only later stages of advanced spoiling. However, it should be remembered that TVB-N readings do not indicate whether the spoiling was caused by bacteria or by the breakdown of proteins (Goulas and Kontaminas, 2005). Likewise, the thiobarbituric acid (TBA) test, one of the most widely used techniques to identify the oxidative deterioration process of food containing fats. Malondialdehyde (MA) is formed because of the degradation of poly-unsaturated fatty acids, because of its early appearance when oxidation takes place and the analytical method's sensitivity (Sallam and Samejima, 2004). The majority of documented food poisoning outbreaks are caused by meat and animal products. Consequently, applying microbiological criteria to assess the quality of those products is crucial (Abuzaid *et al.,* 2020). *Escherichia coli* is one of the major normal intestinal inhabitants of humans and mammals. It is harmless to the host and can cause diseases only in the immune-compromised host or when it breaches the gastrointestinal barriers (Ibrahim *et al.,* 2018). The presence of *E. coli* 0157:H7 in meat samples suggests there may be diseases of fecal origin, improper manufacture processing, and shipment procedures or the use of contaminated water during the animals' evisceration. The higher incidence of entero-pathogenic bacteria in the samples being examined could be the cause of death (Gwida *et al.,* 2014).

MATERIALS AND METHODS

Collection of samples: (Market survey)

The total of sixty random samples of frozen meat products, including Beef Burger, Sausage, Beef kofta and Chicken Nuggets (15 each), were collected from different markets in Assiut City, Egypt. The samples were collected under complete aseptic conditions, wrapped in sterile plastic bags, sealed, labeled, kept in ice boxes and transported to the laboratory. After the package integrity verification, the samples were stored under refrigeration (4°C) until the bacteriological and physico-chemical analysis was performed.

1. Sensory evaluation:

The samples were assessed according to Gracey, (1986); Miller, (1994) and Marriot, (1995). The evaluation of samples was assessed by 5-7 members of the Food Hygiene Department (with past experience in burger processing and evaluation) to evaluate their sensory characteristics. Panel members evaluated the following properties: color, odor and taste.

2. Determination of Monosodium glutamate (MSG):

2.1. Reagents:

Analytical grade of Monosodium Glutamate standard (MSG, 99%) from Sigma Aldrich Company, HPLC grade water, hydrochloride acid (HCl), ophthaldialdehyde powder (OPA), methanol (MeOH), diethyl ether, ophthalaldehyde (OPA-RTU) reagent, 2-

mercaptoethanol, $Na_2B_4O_7$, and Na_2HPO_4 were used. All the used reagents were of analytical grade (Soyseven *et al.,* 2021).

2.2. Preparation of stock solution of MSG:

In HPLC grade water at a concentration of 10 mg/ml. From stock, an intermediate solution was prepared at a concentration of 1 mg/ml. This intermediate solution was used in preparation of the working standard in blank minced meat at a concentration of 0.5, 1, 2, 5, 10, 20 mg/g. Then the spiked sample (working standard) was extracted and prepared as mentioned below.

2.3. Extraction of MSG from the samples:

2.3.1. Samples preparation:

Following Croitoru et al. (2010), one gram of the sample examined was homogenized with 100 mL of 0.10 N HCI solutions. The resulting suspension was sonicated for 20 min. For extraction process, 50 mL of the prepared solution was taken over by adding 50 mL of diethyl ether and mixing thoroughly; then, the diethyl ether was removed. An extraction process was used to remove fatty acids. Each prepared sample was filtered through a 0.22 µm PVDF membrane filter and transferred to a vial after the aqueous phase was collected. All samples were derivatized with the OPA-RTU solution.

2.3.2. Samples Derivatization:

Following Zandy et al. (2017), 27 mg. of OPA powder was added to 1 mL of HPLC grade MeOH, and the mixture was stirred using vortex for 30 seconds to prepare the ophthaldialdehyde (OPA) derivatizing agent. The mixture was then carefully added to 5 mL of mercaptoethanol solution. The OPA derivatization solution was then prepared by adding 9 mL of Na2B4O7 buffer (0.10 M sodium tetraborate, pH = 9.30). The OPA Ready to Use (OPA-RTU) solution was then used to derivatize MSG. Finally, the OPA-RTU contains 1 mg of o-phthaldialdehyde per mL solution, with 2-mercaptoethanol serving as sulphydryl moiety. The 100 µL portions of the generated MSG working standard solution were taken and added to the HPLC vial, and 900 µL of OPA-RTU was added on every part, and the mixture was stirred well with vortex for 5 minutes. All standard working solutions were filtered through a 0.22 m PVDF membrane filter (Demirhan *et al.,* 2015).

2.3.3. Apparatus and chromatographic condition:

The HPLC apparatus is characterized by Agilent Series 1050 quaternary gradient pump, Series 1050 auto sampler, Series 1050 U.V Vis detector, and HPLC 2D Chemstation software (Hewlett-Packard, Les Ulis, France). Chromatographic condition was carried out on a C18 column (Restek RaptorTM) with a mobile phase of 10 mm. phosphate buffer solution (PBS) (pH = 5.90): MeOH (75:25, v/v) at a flow rate of 0.6 mL min-1. The injection volume was 20 µL, the needle was washed with water-MeOH (70:30, v/v), and the detection was performed at 336 nm.

3. Physico-chemical examination (Keeping quality tests):

3.1. Determination of pH (Hydrogen Ion Concentration) :

The pH was obtained at 25°C at the time of calibration according to Assanti et al. (2021). Five grams from each sample were homogenized with 50 ml distilled water for 10-15 minutes. Before measuring, the pH meter was calibrated with standardized buffer solution at pH 7.0 and pH 4.0, with a portable pH meter (Adwa, Waterproof PH Testers AD11, Romania).

3.2. Determination of Total Volatile Basic Nitrogen "TVB-N" :

Following (Kearsley et al., 1983), ten grams sample were macerated with 100 ml. tap water and washed into a distilling flask with 200 ml. distilled water, then 2 grams magnesium oxide were added. A macro-Kjeldahl distillation apparatus was connected to the distillation flask containing 25 ml. of 2% boric acid solution and few drops of methyl-red indicator (0.016 g methyl red, 0.083 g bromocresol green per 100 ethanol) with the receiving tube was dipped below the liquid, with distillation continued till collection of 200 ml. The condenser was then washed with distilled water, and the distillate was titrated with 0.05 M (0.1N) sulphuric acid. The Total Volatile Base Nitrogen (mg./100 gram sample) was calculated as the titration multiply by 14.

TVN/l00g = (mls H_2 So_4 n 0.1 for sample – ml H_2 So_4 n 0.1 for Blank) x 14.

3.3. Determination of Thiobarbituric Acid Number "TBA" :

Following Radha et al. (2014), meat was ground twice before use, where 3 g of sample in a polyethylene bag with 15 ml distilled water were homogenized with a stomacher for 2 min. In a clean test tube, 1 ml of the homogenate, 2 ml of the trichloro acetic acid (TCA)/thiobarbituric acid (TBA) reagent and 50-micron Butylated hydroxyanisole (BHA) were mixed thoroughly using vortex, and then the solution was heated for 15 min. in a boiling water bath. After cooling for 10 min in cold water, they were mixed thoroughly using vortex and centrifuged at 3000 rpm for 15 min. The absorbance of the supernatant was read at 531 nm against a blank that contains all the reagents minus sample, replaced with 1 ml distilled water. The amount of TBRAS was expressed as mg of malondialdehyde (MAD) per kg of meat.

4. Bacteriological examination:

4.1. Detection of Total bacterial Count (TBC) (ISO 4833-1:2013 protocol):

12-15 ml of Plate Count Agar (PCA) media (Oxoid, CM003) were poured into sterile Petri dishes. After solidification, 100 µL. of each sample cultured on plates and incubated at 37ºC for 24 h., then the visible colonies on selected plates were counted. The result was calculated on the basis of the count and the dilution factor. The average number of the two dilutions of each sample was recorded.

4.2. Determination of Total Yeast and mold Count (Y&M Count) (ISO 21527-2:2008):

It was performed for cultivating yeasts and molds and incubated for 5-7 days at 28 ˚C, and the average number of the two dilutions of each sample was counted and presented as log10cfu/g.

4.3. Isolation and identification of *E. coli* 0157:H7*:*

4.3.1. Isolation on Selective enrichment.

Following Tarr et al, (1999), 25 g of sample were weighed aseptically and placed in 225 ml. of modified Vancomycin-Trypticase Soy broth (m-VTSB) supplemented with 40 mg vancomycin liter, stomached at medium speed for 2 min. The homogenate then was transferred to a sterile flask and incubated overnight at 37°C.

4.3.2. Selective plating:

Following **Sallam *et al.* (2013),** each enrichment culture was spread onto Sorbitol MacConkey Agar (Difco 279100), supplemented with 40 mg vancomycin/liter and the plates were cultured by 100 µL of each sample, and then incubated at 37°C for 24 h.

4.3.3. Biochemical identification (FAO, 1992):

Suspected isolates of E. coli were identified according to MacFaddin (2003) and Biochemical confirmation tests according to (FAO, 1992).

4.3.4. Serological identification (ISO, 6887-1, 2013

The isolates were serologically identified according to Kok et al., (1996) and MacFaddin, (2003) by using rapid diagnostic E. coli antisera sets (DENKA SEIKEN Co., Japan) for diagnosis of the Enteropathogenic types.

5. Statistical analysis:
Analysis performed using Microsoft Excel 2010 and Graph Pad Prism version 8: one-way ANOVA using Dunnett's multiple comparisons test computed for each comparison mean value ± S.E. (Standard Error of mean).

RESULTS

Table 1: Results of some sensory characteristics for meat products samples (n=60) (15 for each)

Sensory parameters	Color				Odor				Taste			
Samples	Desirable No.	%	Undesirable No.	%	Desirable No.	%	Undesirable No.	%	Desirable No.	%	Undesirable No.	%
Beef burger	11	3.33	4	26.67	12	80	3	20	13	86.7	2	13.33
Sausage	8	53.33	7	46.67	7	46.67	8	53.33	9	60	6	40
Beef kofta	6	40	9	60	5	33.33	10	66.67	4	26.67	11	73.33
Chicken nuggets	13	86.67	2	13.33	12	80	3	20	14	93.33	1	6.67

Table 2: Results of MSG values (mg/gm.) (n=60) (15 for each)

Meat product	Min.	Max.	Mean± S.E.	Standard limit [a]	Accepted	Not accepted
Beef burger	0.968	2.027	1.415±0.09	≤ 5 mg/gm.	100%	0%
Sausage	1.165	3.122	2.28±0.15	≤ 5 mg/gm.	100%	0%
Beef kofta	1.190	3.467	2.18±0.2	≤ 5 mg/gm.	100%	0%
Chicken nuggets	1.298	4.325	3.34±0.21	≤ 5 mg/gm.	100%	0%

Min.=minimum, Max.=maximum, S.E.=Standard Error of mean
[a] EOSQC: Egyptian Organization for Standardization and Quality Control 2005 recommended that the permissible limits of MSG in meat products must not exceed 5000 ppm (=5 mg/gm.)

Table 3: Results of pH values (n=60) (15 for each)

Meat product	Min.	Max.	Mean± S.E.	Standard limit [a]	Accepted	Not accepted
Beef burger	5.8	6.9	6.37±0.10	5.6-6.2	33.33%	66.67%
Sausage	5.4	6.5	6.22±0.07	5.6-6.2	46.67%	53.3%
Beef kofta	5.7	7	6.45±0.09	5.6-6.2	13.33%	86.67%
Chicken nuggets	5.7	6.6	6.27±0.06	5.6-6.2	53.3%	46.67%

[a] EOS(Egyptian Organization for Standardization): 1522-(2005) for meat products recorded the acceptable limits between 5.6-6.2.

Table 4: Results of TVB-N values (mg/100gm.) (n=60) (15 for each)

Meat product	Min.	Max.	Mean± S.E.	Standard limits [a]	Accepted	Not accepted
Beef burger	4.2	18.2	9.52±1.14	≤20	100%	0%
Sausage	7	26.6	12.13±1.23	≤20	100%	0%
Beef kofta	5.6	12.6	8.87±0.66	≤20	100%	0%
Chicken nuggets	7	15.4	11.11±0.70	≤20	100%	0%

[a] EOSQC (Egyptian Organization for Standards and Quality Control): 63-9 (2006) recommended the standard limits for TVB-N in meat products must not exceed 20 mg/100gm. of sample.

Table 5: Results of TBA values (mg MAD/kg) (n=60) (15 for each)

Meat product	Min.	Max.	Mean± S.E.	Standard limit [a]	Accepted	Not accepted
Beef burger	0.113	0.6	0.35±0.04	≤ 0.9	100%	0%
Sausage	0.15	0.457	0.27±0.02	≤ 0.9	100%	0%
Beef kofta	0.25	0.8	0.4±0.04	≤ 0.9	100%	0%
Chicken nuggets	0.1	0.685	0.23±0.04	≤ 0.9	100%	0%

[a] EOSQC (Egyptian Organization for Standards and Quality Control): No. 63-10 (2006) recommendedthe safe acceptable limit should not exceed 0.9 mg MAD/kg of sample.

Table 6: Results of TBC (cfu/g) (n=60) (15 for each)

Meat product	Min.	Max.	Mean± S.E.	Standard limit
Beef burger	0	$7.75x10^5$	$1.03x10^5±5.12x10^4$	$≤10^5$ [a]
Sausage	0	$9.66x10^5$	$1.43x10^5±6.63x10^4$	$≤10^6$ [b]
Beef kofta	0	$4x10^5$	$6.75x10^4±3.01x10^4$	$≤10^6$ [c]
Chicken nuggets	0	$5x10^5$	$5.33x10^4$ $±3.35x10^4$	$≤10^4$ [d]

[a] Standard limits for TBC in frozen beef burger according to Egyptian Standard (ES): (1688 - 2005) recommended that TBC should not be more than 10^5 cfu/g.
[b] Standard limits for TBC in frozen sausage according to EOSQC: Egyptian Organization for Standards and Quality Control (1972-2005) recommended that TBC should not be more than 10^6 cfu/g.
[c] ES(Egyptian Standards Specifications)(1973-2005) recommended that aerobic plate count (APC) of frozen kofta should not be more than 10^6 cfu/g.
[d] ESS: Egyptian Standard Specification (No.3493/2000) for poultry meat products recommended TBC should not be more than 10^4 cfu/g.

Table 7: Results of Total Y&M Count (cfu/g) (n=60) (15 for each)

Meat product	Min.	Max.	Mean± S.E.	Standard limit [a]
Beef burger	0	$8.41x10^4$	$1.33x10^4±7.12x10^3$	0
Sausage	$1.40x10^2$	$2.50x10^5$	$3.73x10^4±1.66x10^4$	0
Beef kofta	0	$1.21x10^5$	$3.2x10^4±1.04x10^4$	0
Chicken nuggets	0	$1.29x10^5$	$1.98x10^4±9.67x10^3$	0

[a] Standard limits according to EOSQC: (No. 1090-2005) recommended that mold and yeast count must be = 0.

Table 8: Distribution of *E. coli* serotypes among examined 60 samples (15 for each)

Products	Beef burger		Sausage		Beef kofta		Chicken nuggets		Strain Characteristics
Strains	**No.**	**%***	**No.**	**%***	**No.**	**%***	**No.**	**%***	
O11 : H8	1	6.67	1	6.67	----	----	2	13.3	ETEC
O91 : H21	2	13.3	----	----	1	6.67	1	6.67	EHEC
O103 : H4	1	6.67	----	----	----	----	----	----	EHEC
O55 : H7	3	20	----	----	4	26.67	----	----	EHEC
O157 : H7	2	13.3	2	13.3	----	----	1	6.67	EHEC
O26 : H11	----	----	----	----	2	13.3	----	----	EHEC
O159	1	6.67	----	----	----	----	----	----	EIEC
O86	----	----	1	6.67	----	----	----	----	EPEC
O128 : H2	----	----	----	----	1	6.67	----	----	ETEC
Total 60	10		4		8		4		
	66.67%*		26.67%*		53.33%*		26.67%*		
	16.67%**		6.67%**		13.3%**		6.67%**		

EPEC = Enteropathogenic *E.coli,* **EIEC** = Enteroinvasive *E.coli*, **ETEC** = Enterotoxigenic *E.coli***,** **EHEC** = Enterohaemorrhagic *E.coli*
* Percentage in relation to total number of each sample (15), ** Percentage in relation to total number of samples (60).

Table 9: Incidence of *E. coli* 0157:H7 among examined 60 samples (15 for each)

Products	Beef burger		Sausage		Beef kofta		Chicken nuggets		Total	%**
Strains	**No.**	**%***	**No.**	**%***	**No.**	**%***	**No.**	**%***		
E.coli 0157:H7	2	13.3	2	13.3	----	----	1	6.67	5	
	3.33%**		3.33%**				1.67%**			8.3

* Percentage in relation to total number of each type (15), ** Percentage in relation to total number of samples (60).

DISCUSSION

1. Sensory evaluation

The findings in Table (1) demonstrated that beef burger and chicken nuggets recorded higher quality in these organoleptic characters, as they recorded desirable color with 73.33 and 86.67 %, respectively. Also, they recorded desirable odor with 80% for each of them, and recorded desirable taste with 86.67 and 93.3 %, respectively. On the other hand, the percentage of undesirable chicken nuggets: color, odor and taste were 13.33, 20 and 6.67%, respectively, which was almost similar to that obtained by El-Kewaiey, (2012). Regarding sausage color, odor and taste, the percentage of undesirable samples was 46.67%, 53.33% and 40%, respectively. The results obtained were higher than those reported by Hassanien *et al.* (2018). In general, beef kofta samples recorded the lower quality in color, odor and taste with 40, 33.3 and 26.67 %, respectively. These results agree with that recorded by Abdelkader *et al.* (2017) as the kofta recorded the lowest accepted percent among the samples evaluated.

2. Determination of MSG

As shown in Table (2), results revealed that the MSG mean± S.E. values (mg/gm.) in beef burger samples were the lowest concentration levels, with a mean±S.E value of (1.415± 0.09) followed by (2.18± 0.2) in beef kofta. Moreover, the highest level recorded in chicken nuggets with a mean±S.E value of (3.34±0.21), followed by (2.28±0.15) in sausage samples. Results revealed that all levels were accepted according to EOSQC: Egyptian Organization for Standardization and Quality Control (2005), as recommended that the permissible limits of MSG in meat products must not exceed 5000 ppm (=5 mg/gm.). Regarding previous studies for MSG in beef burger samples, Ayad (2022) and Rodriguez *et al.* (2003) recorded (1.73) and (1.457), respectively, which were higher than the present study. In contrast, Amin *et al.* (2018) recorded (1.140 mg/gm.), which was lower than the present study. Regarding sausage samples, other studies recorded much higher values, like (5.4) by Demirhan *et al.* (2015). In contrast, Amin *et al.* (2018) recorded a lower value (1.959 mg/gm) than the current study. Moreover, for beef kofta samples, other studies by Ayad (2022) recorded (1.47), which was lower than this study. On the other hand, Soyseven *et al.* (2021) recorded (21.3) mg/gm. which was much higher than this study. Also, for chicken nuggets samples, values nearly similar to our study recorded by Ayad (2022). Sabikun *et al.* (2021) recorded (210.8), which was much higher than this study. But Hassan *et al.* (2018) recorded (1.399), which was lower than this study.

3. Determination of pH (Hydrogen Ion Concentration):

As shown in Table (3), results revealed that the mean±S.E values of pH were (6.37±0.10) in beef burger samples; (6.22±0.07) in sausage; (6.45±0.09) in beef kofta and (6.27±0.06) in chicken nuggets, respectively. According to the Egyptian Organization for Standardization (EOS): (1522-2005) for meat products, the mean values for beef kofta and beef burger samples were above the permissible limits, as the acceptable limits were between 5.6-6.2. These results agreed with Glorieux *et al.* (2017), as pH value for meat product sample recorded (7.42) when TSP (Tri-Sodium Phosphate) was used, as pH increased by 1.41 units. This was expected, since TSP has the most alkaline effect or may be due to increasing proteolytic activity with the formation of peptides, amino acids, non-protein nitrogen compounds, and the formation of alkaline groups over storage. Another study for beef burger samples recorded (5.8) (Hassanien *et al.,* 2018), which was lower than our study. On the other hand, El Bayoumi *et al.* (2023) and Kamal Ibrahim Ragab (2011) recorded (6.20) and (6.216), respectively, which were nearly similar to this study. Also, for sausage samples, El-Shabrawy (2015) recorded (5.62), which was lower than the current study. But El Bayoumi *et al.,* 2023 recorded (6.27), which was nearly similar to this study. Moreover, for beef kofta samples; Hassanien *et al.* (2018) and El Bayoumi *et al.* (2023) recorded (5.89) and (5.88), respectively, which were lower than this study. In addition, for chicken nuggets samples, Hussain *et al.* (2016) recorded (5.66) and Al-Dughaym and Altabari (2010) recorded (6.03) in different manufacturers, which were lower than the current study.

4. Determination of Total Volatile Basic Nitrogen "TVB-N":

As shown in Table 4, results revealed that the mean values± S.E of TVB-N were (9.52±1.14) mg/100gm. in beef burger samples; (12.13±1.23) in sausage; (8.87±0.66) in beef kofta and (11.11±0.7) in chicken nuggets and all the examined samples were within the safe and acceptable limit (should not exceed 20 mg/100 gm.) as recommended by EOS: 63-9 (2006). In another study for beef burger samples, El Bayoumi *et al.* (2023) recorded (11.19), which was nearly similar to our study. On the other hand, Hassanien *et al.* (2018) recorded (17.01), which was higher than the current study. In addition, for sausage samples, Hassanien *et al.* (2018) recorded (16.23), which was nearly similar to this study. In contrast, El-Shabrawy (2015) recorded (6.2), which was lower than this study. Regarding beef kofta samples, Kortoma (2016) reported (12.6), which was nearly similar to the current study, but El-Shabrawy (2015) recorded (5.23), which was lower than this study. On the other hand, a much higher value (15.69±0.91) reported by El Bayoumi *et al.* (2023), which clarified that the causes refer to a post-processing environment, particularly at the shop level, or failure in freezing storage during distribution. Also, for chicken nuggets samples, El-Kewaiey (2012) recorded (13.36±0.76), which was nearly like the current study. On the other hand, Hussain *et al.* (2016) recorded (20.83), which was much higher than this study.

5- Determination of Thiobarbituric Acid Number "TBA value":

As shown in Table (5), the results revealed that the TBA values±S.E were (0.35±0.04) mg MAD/kg in beef burger samples; (0.27±0.02) in Sausage; (0.4±0.04) in beef kofta and (0.23±0.04) in chicken nuggets, respectively. Mean values of TBA in all the examined meat products recorded were within the safe and acceptable limit (should not exceed 0.9 mg malondi-aldehyde/kg of sample), as recommended by EOS: 63-10 (2006). Protein-lipid oxidation product interactions that alter the functional structure of proteins and cause a decline in flavor, color, and texture, as well as an increase in the percentage of unwanted taste and odor of beef kofta samples, as recorded in results of sensory characters in table 1. In another study for beef burger samples; El Bayoumi *et al.* (2023) recorded (0.39±0.01 mg MAD/kg), which was nearly like the current study. Also, Malak and Abdelsalam, (2021) recorded (0.66±0.02), which was slightly higher than the current result. On the other hand, Elsherif *et al.* (2022) recorded (0.25±0.025), which was lower than this study. Regarding sausage samples, El Bayoumi *et al.* (2023) and Kortoma (2016) recorded (0.51) and (0.68), respectively, which were higher values than this current study. Also, for beef kofta samples, Hassanien *et al.* (2018) and Kamal Ibrahim Ragab (2011) recorded (0.7) and (0.863), respectively, which were higher than this study. In addition, for chicken nuggets, El Tahan *et al.* (2006) recorded (0.22) for samples from Shubra retail markets in Egypt which was similar to the current study. But El-Kewaiey (2012) recorded (0.038), which was lower than this study. On the other hand, Al-Dughaym and Altabari (2010) recorded (0.53) and (2.09) from different manufacturers which were much higher value than the current study.

6. Bacteriological examination:

Foodborne diseases (FBD) represent global public health issues, resulting in considerable morbidity and mortality in all age groups (He *et al.* 2023). The contamination of meat products with microorganisms from meat handlers, which may have carried the pathogenic microorganism during the processes of packing, manufacturing and distribution. Poor hygiene during production processes, refrigeration or retail and storage of foods or improper cooking may lead to food poisoning or meat borne illness, causing an increase in disease burden and consequent death in most developing countries (FDA, 2012). For these reasons, determination of TBC and Total Y&M Count is critical and the findings of *E.coli* 0157:H7 were held in this study.

6.1. Determination of Total Bacterial Count (TBC):

As shown in Table (6), results revealed that the TBC values±S.E were ($1.03x10^5 \pm 5.12x10^4$) in beef burger samples, which were slightly higher than the accepted limits for TBC in frozen beef burger according to E.S. "Egyptian Standards" (2005) (1688-2005). Also, in sausage it recorded ($1.43x10^5 \pm 6.63x10^4$), which were within the permissible limits according to EOS (1972-2005). In addition, in beef kofta it recorded ($6.75x10^4 \pm 3.01x10^4$) which were slightly higher than the accepted limits recomm-ended by E.S.S. (Egyptian Standards Specifications) (2005) (1973-2005). Moreover, in chicken nuggets it recorded

($5.33x10^4$ ±$3.35x10^4$), which was above the permissible limits according to E.S.S. (2005), No. (3493/2000) for poultry meat products, despite recording mean ± S.E (3.34±0.21) mg/gm, which was the highest concentration recorded for MSG, which is must control the microbial contamination regarding its preservation effect in meat products manufacturing. And these unaccepted products samples represent high risk to consumers and cause health hazards and indicate inadequate sanitary conditions during distribution and storage or using dirty equipment and improper handling during stages of manufacturing. Other studies for beef burger samples; Hassanien *et al.* (2015) recorded ($7.34x10^4$±$1.22x10^4$), which was nearly similar to this study. Also, higher values than the current study were reported before ($4.2X10^5$±$1.3X10^5$) (Shaltout *et al.,* 2022). Also, for sausage samples, Salem *et al.* (2018) recorded ($1.23×10^5$ ±$5.88×10^4$) which was nearly similar to the current study. In contrast, higher values than this study reported by Ali *et al.* (2023), which recorded ($7.90x10^5$±$0.15x10^5$). Moreover, for beef kofta samples, Abuelnaga *et al.* (2021) recorded ($6.1×10^5$±$3.1×10^5$) which was higher than this study. On the other hand, lower results are lower than our study reported by Shaltout *et al.* (2022), which recorded ($2.5X10^4$± $2.2X10^3$). In addition, for chicken nuggets, Gaafar *et al.* (2019) recorded ($5.8x10^6$ ±$0.09x10^6$) which were higher than this study. On the other hand, Morshdy *et al.* (2023) recorded (5.18±0.19 log10) which was lower results than this current study.

6.2. Determination of Total Yeast and mold Count (Total Y&M Count):

As shown in Table (7), results revealed that the total yeast and mold Count values ± S.E were ($1.33x10^4$±$7.12x10^3$) cfu/g in beef burger samples ($3.73x10^4$± $1.66x10^4$) in sausage; ($3.2x10^4$±$1.04x10^4$) in beef kofta and ($1.98x10^4$±$9.67x10^3$) in chicken nuggets. All the samples examined exceeded the permissible limits, according to EOSQC, (2005).

According to previous studies for beef burger samples, Abuelnaga *et al.* (2021) recorded ($1.4×10^3$±9×10) for total yeast count and ($1.3×10^3$±$9.2×10^2$) for total mold count, respectively. These results are nearly similar to the current study. In addition, Salem *et al.* (2018) recorded ($1.63×10^4$±$5.53×10^3$) which was lower than the current study. On the other hand, Elsherif *et al.* (2022) recorded ($3.9×10^4$± $1.2×10^4$), which was higher than this study and the major cause of refrigerated food deteriorating caused by fungi, when low water activity, high acidity, or packing circumstances fungi growth over bacteria in foods (Oluwaseun *et al.,* 2018). Also, for sausage samples, Abuzaid *et al.* (2020) recorded ($1.1x10^3$±$0.14x10^3$) for total mold and ($0.52x10^3$±$0.08x10^3$) for total yeast, respectively, which were lower than this study. On the other hand, El-Tawab, (2014) recorded ($7.63x10^4$±$1.79×10^4$) which was higher than this study. Moreover, other studies for Beef kofta; lower results than this study reported by Abuzaid *et al.* (2020) which recorded ($1.4x10^3$±$0.27x10^3$) and ($0.47x10^3$±$0.07x10^3$) for total mold and yeast, respectively. In addition, for chicken nuggets; Khalafalla *et al.* (2019) and Bkheet *et al.* (2007) recorded (20±12) and ($1.4x10^4$±$2.4x10^2$), respectively, which were lower than the current study.

6.3. Isolation, identification and serological examination for *E.coli*:

As shown in Table (8), the prevalence of *E. coli* in examined beef burger samples was (10/15) (66.67%); in sausage was (4/15) (26.67%); in beef kofta was (8/15) (53.3%) and in chicken nuggets was (4/15) (26.67%). In other studies for prevalence of *E. coli* in beef burger samples, El Bayoumi *et al.* (2023) detected (5/40) (12.5%), which was lower than this study.

In addition, for sausage samples, higher results than our study by Salem *et al.* (2018) detected (20/25) (80%). In other studies for beef kofta samples, Shaltout *et al.* (2022) detected (40%) which was lower result than this current study. Moreover, for chicken nuggets samples, lower results than this study reported by Gaafar *et al.* (2019), which recorded (2/30) (6.67%), but El-Kewaiey (2012) failed to detect *E. coli* in examined chicken nuggets samples.

Moreover, as shown in Table (9), the achieved results of this study pointed out that *E. coli* 0157:H7 was isolated from 2 (13.3%) beef burger samples, 2 (13.3%) of sausage samples also detected in only one of chicken nuggets samples with prevalence (6.67%), but were not found in beef kofta samples. Other studies reported by Antown and Dapgh (2009), who detected *E.coli* 0157:H7 in (6%) of beef burger samples, which was lower incidence than this study. On the other hand, El-Shenawy *et al.* (2022) reported *E.coli* 0157:H7 in (15/30) 50% which was a much higher value than this current study. But Sotohy *et al.* (2019) couldn't record it in beef burger samples. Also, Antown and Dapgh (2009) detected (4%) in beef kofta and failed to be detected in sausage samples.

CONCLUSION

Assessment of Monosodium Glutamate (MSG) levels in Egyptian meat products was reported for the first time by researchers of the Faculty of Veterinary Medicine in Assiut University. The measurements estimated on these random 60 frozen meat products samples, which included beef burger, sausage, beef kofta and chicken nuggets (15 for each), indicated that the overall desirable grades of sensory evaluations for beef burger, sausage and chicken nuggets were above 50% for color, odor and taste evaluation, and this contrasted with beef kofta samples, which recorded the lower quality in color, odor and taste with 40, 33.3 and 26.67 %, respectively. Moreover, for MSG (mg/gm.), TVB-N (mg/100gm.) and TBA (mg MAD/kg) values in this study, all mean values were accepted and within the Egyptian standard limits, as beef burger samples recoded (1.415, 9.52 and 0.35); sausage recoded (2.28, 12.13 and 0.27); beef kofta recorded (2.18, 8.87 and 0.4) and chicken nuggets recorded (3.34, 11.11 and 0.23). In addition to pH measurement, some samples were above the Egyptian standard permissible limits, as the not-accepted samples of beef burger, sausage, beef kofta and chicken nuggets samples recorded (66.67%, 53.3%, 86.67% and 46.67%), respectively. Also, TBC (cfu/g) mean values were almost above the Egyptian standard permissible limits in all samples, except sausage samples were within the limits. Despite recording the highest concentration for MSG with a mean value (3.34) mg/gm. On the chicken nuggets samples, the TBC in these samples exceeded the permissible limits. As MSG must control microbial contamination regarding its preservation effect in meat products manufacturing. On the other hand, the Total Y&M Count (cfu/g) mean values were all above the permissible limits according to Egyptian Standard Specifications. The high counts of TBC and presence of yeast and mold may refer to bad hygiene during processing or inadequate storage and distribution methods. Presence of *E.coli* 0157:H7 in 2 (13.3%) of both beef burger and sausage samples and in 1 (6.67%) of chicken nuggets samples might pose a potential health hazard to consumers and be a source of food-born illness.

RECOMMENDATION

As it might be quite easy to reach the level of abuse usage of MSG because it appears hard to evaluate daily intake, due to the unknown levels of chemicals included in processed foods and fast-food menus. Also, long periods of consumption have major toxic effects. For this reason, it is recommended to use natural alternatives for MSG, which give the same desirable taste for consumers without any hazards. Also, consumers have a far wider selection of foods that are more affordable, high-quality, that is why it is crucial to maintain using proper technology in hygienic conditions, good quality raw material, qualified employees must be hired at every stage in the production, adequate methods for storage, and also routine analysis must be applied regularly by researchers to ensure that it is safe and healthy for consumption, in order to control public health hazard.

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تقييم الصوديوم أحادي الجلوتامات ، جودة الخصائص الحسية ، الفيزيائية ـ الكيميائية والميكروبيولوجية في بعض منتجات اللحوم

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هدفت هذه الدراسة إلى تقييم قيمة أحد المضافات الغذائية الضارة المستخدمة في إنتاج الغذاء، وهي الصوديوم أحادي الجلوتامات ، بالإضافة إلى تقييم الجودة الحسية والفيزيائية-الكيميائية والميكروبيولوجية في بعض منتجات اللحوم المجمدة. تم جمع ٦٠ عينة عشوائية شملت بيف برجر، السجق، كفتة اللحم البقري، وقطع الدجاج (ناجتس) بواقع ١٥ عينة لكل منها، وذلك من متاجر مختلفة في مدينة أسيوط، مصر. كشفت النتائج أن عينات كفتة اللحم البقري سجلت أدنى درجات التقييم الحسي مقارنةً بعينات البيف برجر وقطع الدجاج (ناجتس)، والتي سجلت أعلى الدرجات. بالنسبة لمستويات الصوديوم أحادي الجلوتامات (مجم لكل جم) ، فقد أظهرت النتائج أن متوسطات التركيزات كانت على النحو التالي: (١,٤١٥) في البيف برجر, (٢,٢٨) في السجق , (٢,١٨) في كفتة اللحم البقري و(٣,٣٤) في قطع الدجاج (ناجتس). علاوة علي ذلك تم تحديد قيمة تركيز الاس الهيدروجيني، وكانت المتوسطات كما يلي: (٦,٣٧) في البيف برجر،(٦,٢٢) في السجق، (٦,٤٥) في كفتة اللحم البقري و (٦,٢٧) في قطع الدجاج (ناجتس). بالإضافة إلى ذلك، تم تحديد متوسطات قيمة المركبات النيتروجينية القاعدية الطيارة TVB-N (mg/100gm.) والمواد المتفاعلة مع حامض الثيوباربيتيوريك TBA (mg MAD/kg) ، وكانت القيم كالتالي: (٩,٥٢ و ٠,٣٥) في البيف برجر، (١٢,١٣ و ٠,٢٧) في السجق، (٨,٨٧ و ٠,٤) في كفتة اللحم البقري و (١١,١١ و ٠,٢٣) في قطع الدجاج (ناجتس)، حيث كانت جميع هذه القيم ضمن الحدود المسموح بها وفقًا للمواصفات القياسية المصرية. أما بالنسبة للفحص البكتريولوجي، فقد أظهرت النتائج أن المتوسطات لكل من Total Y&M Count (cfu/g) وTBC كانت كما يلي: (١,٠٣×10^5 ± ٥,١٢×10^4 و ١,٣٣×10^4 ± ٧,١٢×10^3) في البيف برجر، (١,٤٣×10^5 ± ٦,٦٣×10^4 و ٣,٧٣×10^4 ± ١,٦٦×10^4) في السجق، (٦,٧٥×10^4 ± ٣,٠١×10^4 و ٣,٢×10^4 ± ١,٠٤×10^4) في كفتة اللحم البقري و(٥,٣٣×10^4 ± ٣,٣٥×10^4 و ١,٩٨×10^4 ± ٩,٦٧×10^3) في قطع الدجاج (ناجتس). وبالنسبة للبكتيريا الايشريكية القولونية O157:H7 تم تحديد البكتيريا سيرولوجيًا في عينتين (١٣,٣٣٪) لكلا من البيف برجر والسجق وفي عينة واحدة (٦,٦٧٪) من قطع الدجاج (ناجتس). وأشارت هذه النتائج التي تم الحصول عليها إلى أهمية تطبيق ممارسات النظافة الصارمة على عمليات إنتاج اللحوم لمنع وجود المنتجات ذات الجودة المنخفضة والأمراض المنقولة بالغذاء.