Benha Veterinary Medical Journal 43 (2023) 91-96

Official Journal Issued by Faculty of Veterinary Medicine

Benha Veterinary Medical Journal

Journal homepage: https://bvmj.journals.ekb.eg/

Since 1990

Original Paper

Experimental Study on the Effect of *Propionibacterium* and Acetic acid on *Candida albicans* contamination in chicken fillet Stored at Chilling Conditions

Fahim, A. Shaltout[1], Ramadan, M. Salem[2], Eman, M. Eldiasty[2], Fatma, A. Diab[3*]

[1] *Food Hygiene and Control Department, Faculty of Veterinary Medicine, Benha University, Egypt*

[2] *Mycology Department, Animal Health Research Institute, ARC, Egypt*

[3] *Veterinarian at Benha University Hostel, Benha University, Egypt*

ARTICLE INFO

Keywords

Probiotic

Organic acid

Meat products

Candida albicans

Received 23/09/2022
Accepted 03/10/2022
Available On-Line 15/01/2023

ABSTRACT

The current experimental study aimed to investigate the inhibitory effects of two food additives (*Propionibacterium* and acetic acid) at four different concentrations (0.5, 1.0, 2.5 and 5%) on *Candida albicans* (*C. albicans*) including recording their impact on the sensory characteristics of the treated chicken fillet samples in chilling conditions (4±1^{O}C). After physical and microbial examination for nine days of storage, results showed significant improvement in the sensory characteristics of the treated samples, especially with increasing the concentration of the tested additives when compared with the control untreated samples, which were spoiled on the 9th day of inoculation. Regarding the anti-*C. albicans* effect of the tested materials, in general, *C. albicans* showed a higher reduction percent with increasing the concentration of the inoculated additives; furthermore, the treated samples with 2.5% and 5.0% acetic acid, after nine days of inoculation, showed more reduction in *C. albicans* counts (70.7% and 87.2%) than the treated samples with *Propionibacterium* of the same concentration (41.4% and 52.7%), respectively. Referring to the obtained results, *Propionibacterium* and acetic acid (2.5% and 5.0%) can be considered good choices for preserving and enhancing the quality of chilled chicken fillets and may be recommended for their usage in chicken fillet preservation as safe and easily applied food additives.

1. INTRODUCTION

Chicken meat is among the foods preferred by consumers in Egypt and throughout the universe because of its nutritional value and reasonable price (Abdelrahman *et al.*, 2020 and Shaltout, 2022). However, with the increased consumption of meat and meat products, the incidence of foodborne disease outbreaks linked to meat has increased significantly. Due to its qualities that can lead to quick and severe spoiling, which mostly begins at slaughterhouses through the transmission of microbes between the corpses, chicken meat is a particularly perishable commodity (Lianou *et al.*, 2017 and Shaltout, 2002).

From an economic point of view, mould and yeast are microorganisms that have a serious economic impact on the poultry meat industry throughout acceptability drawbacks because of its ability to produce extracellular proteolytic and lipolytic enzymes that initiate the protein and fat deterioration, which make it of lower nutritional value and apparently unacceptable (Mahmoud *et al.*, 2020 and Shaltout *et al.*, 2019a).

Bacteriocins or probiotics have been used in several attempts to inactivate microbial contaminants in chicken meat. Probiotics are safe food-additives defined as mono- or mixed cultures of living microorganisms that have been used in several trials to inactivate foodborne microbial contamination because of its beneficially effect in reducing disease risk, and increasing resistance to infection through improvements in pH, color, water-holding capacity, fatty acid profile, and oxidative stability in fresh meat (Kerry *et al.*, 2018 and Saleh, 2014).

Propionibacterium is one of the probiotic's family, which is considered as an appealing candidate for advancing studies about the beneficial effect of probiotics in food industry, as it produces short-chain unsaturated fats and surface proteins through carbohydrate fermentation, that positively enhance human health (Argañaraz-Martínez *et al.*, 2013; Blasco *et al.*, 2015; Nair *et al.*, 2019 and Shaltout *et al.*, 2019b). Moreover, organic acids like acetic, citric, and lactic acids, which are recognized as safe substances for use in food production, have been frequently used to decontaminate chicken meat products due to their antimicrobial effectiveness, easily application, and it may also play an important role in the tenderness and flavoring of the processed meat (Nkosi *et al.*, 2021 and Berge *et al.*, 2001).

Candidiasis represents the fourth leading cause of nosocomial infections, and mortality due to systemic candidiasis remains high, ranging from 15% to 35% depending on the infecting Candida species (Pal, 1997). Due to the increased number of immunocompromised people, candidiasis remains a persistent public health problem of the world. The person who are suffering from diabetes, malnutrion, cancer, HIV/AIDS, neutropenia, metabolic dysfunction, receiving antibiotics, cytotoxic

* Corresponding author: fatma.hameddiab@gmail.com

drugs for prolonged period, and undergoing dialysis, renal transplantation, catheterization are at a greater risk of acquiring Candida infections (Pal, 2007). Candida infection can spread between patients in healthcare settings. The global incidence of Candida bloodstream infections is recorded 400,000 cases each year (Pal, 2014). The present communication delineates the growing importance of candidiasis as an opportunistic mycosis of global public health concern.

Therefore, the following study was conducted to evaluate the anti-mycotic effect of *Propionibacterium* and acetic acid of different concentrations against *C. albicans* in the experimentally infected chicken fillet, and their effects on its sensory properties.

2. MATERIAL AND METHODS

2.1. Collection of chicken fillet samples:

Raw chicken breast fillet samples (about 1,125 g) were purchased from a local poultry meat grocery in Qalubiya governorate, Egypt. The collected samples were transferred and stored aseptically in 4±1^{O}C.

2.2. Preparation of spore suspension of C. albicans:

The *C. albicans* strain (Genbank accession number: AYMC2 0.00122) was used in the present study. *The Candida albicans* strain was subcultured and incubated for 48h on Malt extract agar, collected, and washed with 10 ml of sterile distilled water in 2% Tween-80. The spore suspension was standardized by plating assay (Shaltout *et al.*, 2019a), counting and calculating to reach 10^7 CFU/ml.

2.3. Preparation of the used additives:

Preparation of Propionibacterium

Propionibacterium obtained from Gencore int. inc. Ann Arbor, Mi, USA by Health Family Co., stoke solution was performed according to the product leaflet, then made other dilutions of 0.5%, 1.0%, 2.5%, and 5% by using sterile dis. water.

Acetic acid preparation

Acetic acid (99.0% conc) was obtained from Republic chemicals company, Egypt. By sterile Dist. Water, different dilutions were prepared (0.5%, 1%, 2.5% and 5% conc).

2.4. Preparation food model:

The collected fillet samples were washed and rinsed with sterile distilled water. The fresh chicken breast was cut into pieces of approximately (10 cm x 10 cm) using a sterile knife. The pieces were kept in sterile open Petri-dishes and exposed to ultraviolet rays (at 254 nm) for 15 minutes on each side to minimize the superficial commensals.

Chicken fillet samples were divided into 4 groups, the first group was considered a positive control untreated group (G1) of about 200 g weight. The 2nd (G2) and 3rd (G3) groups were each divided into four groups, about 200g weight / each (for the following treatment with the four concentrations of *Propionibacterium* and acetic acid, 0.5, 1.0, 2.5, and 5.0%). The 4th group (G4) was kept untreated in a refrigerator and used for organoleptic examination, about 500 g in weight.

2.5. Experimental procedures:

First, the G1, G2, and G3 were inoculated with *C. albicans* by dipping in the previously prepared spore suspension (10^7 CFU/mL) for 30 minutes.

The 2nd group was subdivided into four portions. Each portion was treated with *Propionibacterium* by soaking in 2 mL of previously prepared 0.5%, 1.0%, 2.5% and 5% conc solution.

The 3rd group was subdivided into four portions. Each portion was treated with acetic acid by soaking in 2 mL of previously prepared 0.5%, 1.0%, 2.5%, and 5% conc solutions.

NB. The 1st, 2nd, and 3rd inoculated samples with *C. albicans* were incubated, before soaking in the tested additive, for 30 minutes at 25^{O}C; then kept for another 30 minutes at room temperature (25^{O}C) to enhance the yeast spore attachment.

All samples were stored at 4±0.2^{O}C for 9 days and *C. albicans* counts were recorded at zero time, 48hrs, 4 days, 6 days, and 9 days.

The 4th group was kept chilled without any treatment for the organoleptic scoring.

After that, the prepared groups were subjected to the following examinations:

Organoleptic examination

Color, texture, and odor were evaluated by 3 trained panelists following the recommendations of (Collins and Huey, 2015) for color scoring, texture scoring through boiling and roasting test, and odor scoring. The color, texture, and odor of the collected samples were scored using a 9-point hedonic scale**.**

Determination of C. albicans count

After preparation of the samples following (ISO, 2017) for preparation of tenfold serial dilutions, C. albicans was counted according to (ISO, 2008) by pour-plate technique on duplicated Petri-dishes of malt extract agar, and then incubated in an inverted position at 37^{O}C for 48 to 72 hrs.

Statistical analysis

After triplicate examinations of the designed treatment experiment, the obtained data were statistically evaluated by application of the Analysis of Variance (ANOVA) test according to (Feldman et al., 2003); values were presented as Mean ± standard error.

Calculation of reduction percent

Reduction % = $\left(\frac{(B-A)}{A}\right) x100$

A = control reading

B = reading after treatment

3. RESULTS

According to the obtained results of sensory evaluation of the treated chicken fillet, add of *Propionibacterium* and acetic acid of different concentrations improved the physical characteristics in comparison with the control untreated samples, especially with increasing its concentration. Referring to the recorded results in Table (1), the treated groups with *Propionibacterium* and acetic acid of 2.5 and 5.0% showed high acceptability scores after the 9th day of incubation with the mild superiority of the treated samples with *Propionibacterium*, while appearing spoiled in the other tested groups.

Moreover, experimental investigation of anti-yeast effect on *C. albicans*, as recorded in Tables (2 and 3), revealed significant reduction in its count, which got higher with increasing the concentration of the tested additives along nine days of the examination. The addition of *Propionibacterium* and acetic acid (2.5 and 5.0%) showed high reduction percent with significant superiority of acetic acid (70.7 and 87.2%) than Propionibacterium (41.4 and 52.7%), respectively.

Referring to the obtained results, *Propionibacterium* and acetic acid showed an enhanced effect on the sensory and microbial count appeared as elongated shelf-life with lower microbial count in comparison with the control untreated group.

Table 1 Sensory evaluation of the treated groups compared with control group.

Groups		Parameter	Zero time	2nd day	4th day	6th day	9th day
Control		Color	++++	+++	++	+	S.
		Odor	++++	+++	++	+	S.
		Texture	++++	++++	+++	+	S.
Propionibacterium	0.5%	Color	++++	+++	++	+	S.
		Odor	++++	+++	++	+	S.
		Texture	++++	++++	++	+	S.
	1.0%	Color	++++	+++	++	+	S.
		Odor	++++	+++	++	+	S.
		Texture	++++	++++	++	+	S.
	2.5%	Color	++++	++++	++++	+++	+++
		Odor	++++	++++	++++	+++	+++
		Texture	++++	++++	++++	+++	+++
	5.0%	Color	++++	++++	++++	++++	++++
		Odor	++++	++++	++++	++++	++++
		Texture	++++	++++	++++	++++	++++
Acetic acid	0.5%	Color	++++	+++	++	+	S.
		Odor	++++	+++	++	+	S.
		Texture	++++	+++	++	+	S.
	1.0%	Color	++++	++++	+++	++	S.
		Odor	++++	++++	+++	++	S.
		Texture	++++	++++	+++	++	S.
	2.5%	Color	++++	++++	++++	+++	+++
		Odor	++++	++++	++++	+++	+++
		Texture	++++	++++	++++	+++	+++
	5.0%	Color	++++	++++	++++	+++	+++
		Odor	++++	++++	++++	+++	+++
		Texture	++++	++++	++++	+++	+++

++++: excellent +++: very good ++: good +: bad S.: spoiled

Table 2 Antifungal activity of various concentrations of Propionibacterium and Acetic acid different treated fillet chicken meat during storage at 4±1OC.

Treat / Time	Control	P 0.5%	P 1.0%	P 2.5%	P 5.0%	A 0.5%	A 1.0%	A 2.5%	A 5.0%
Zero	6.49±0.01^{a}	6.49±0.01^{a}	6.49±0.01^{a}	6.49±0.01^{a}	6.49±0.01^{a}	6.49±0.01^{a}	6.49±0.01^{a}	6.49±0.01^{a}	6.49±0.01^{a}
2nd day	8.1±0.1^{a}	5.9±0.1^{b}	5.5±0.1^{bc}	5.3±0.1^{cd}	5.1±0.1^{e}	5.0±0.04^{e}	3.6±0.3^{f}	2.4±0.04^{g}	1.2±0.1^{h}
4th day	6.5±0.2^{a}	5.4±0.1^{b}	5.1±0.06^{bc}	4.7±0.1^{c}	3.7±0.1^{d}	4.0±0.01^{d}	3.1±0.1^{e}	2.3±0.1^{f}	1.03±0.05^{g}
6th day	5.9±0.1^{a}	5.5±0.2^{b}	4.9±0.03^{bc}	4.5±0.04^{cd}	3.1±0.08^{d}	S.	3.8±0.03^{d}	2.0±0.09^{e}	0.79±0.01^{f}
9th day	S	S	S	3.8±0.03^{a}	3.07±0.2^{b}	S	S	1.9±0.08^{c}	0.83±0.07^{d}

P. Propionibacterium; A. Acetic acid; S. Spoiled
Results are expressed as mean ± S.E.M.
a, b & c: There is no significant difference (P>0.05) between any two means, within the same row (of each group) have the same superscript letter.
Control: Untreated group.
P 0.5%: Treated group with *Propionibacterium* (0.5%) P 1.0%: Treated group with *Propionibacterium* (1.0%) P 2.5%: Treated group with *Propionibacterium* (2.5%)
P 5.0%: Treated group with *Propionibacterium* (5.0%) A 0.5%: Treated group with Acetic Acid (0.5%) A 1.0%: Treated group with Acetic Acid (1.0%)
A 2.5%: Treated group with Acetic Acid (2.5%) A 5.0%: Treated group with Acetic Acid (5.0%)

Table 3 Reduction % of total yeast (C. albicans) count in treating fillet chicken meat.

Treat / Time	P 0.5%	P 1.0%	P 2.5%	P 5.0%	A 0.5%	A 1.0%	A 2.5%	A 5.0%
Zero	--	--	--	--	--	--	--	--
48h (2nd day)	9.1	15.3	18.6	21.4	23.0	44.5	63.0	81.5
96h (4th day)	16.8	21.4	27.6	43.0	38.4	52.2	64.6	84.5
144h (6th day)	15.3	24.5	30.7	52.2	--	41.4	69.2	87.8
216h (9th day)	S.	S.	41.4	52.7	S.	S.	70.7	87.2

P. Propionibacterium; A. Acetic acid; S. Spoiled Reduction percent = $\left(\frac{(B-A)}{A}\right)$ x100 A = control reading from Table (2) B = reading after treatment from Table (2)
P 0.5%: Treated group with *Propionibacterium* (0.5%) P 1.0%: Treated group with *Propionibacterium* (1.0%) P 2.5%: Treated group with *Propionibacterium* (2.5%)
P 5.0%: Treated group with *Propionibacterium* (5.0%) A 0.5%: Treated group with Acetic Acid (0.5%) A 1.0%: Treated group with Acetic Acid (1.0%)
A 2.5%: Treated group with Acetic Acid (2.5%) A 5.0%: Treated group with Acetic Acid (5.0%)

4. DISCUSSION

The introduction of new additives and/or techniques in the processed meat industry to improve the nutritional and shelf-life quality of the meat products while keeping the consumer acceptability is a new challenge nowadays (Shaltout *et al.*, 2019a and Ursachi *et al.*, 2020).

Large amounts of food and feed are lost yearly because of mould and yeast spoilage. Bio-preservation by *Propionibacterium* has gained increased interest and might be particularly useful due to its important role in many food fermentations. *Propionibacterium* plays an antifungal effect in the food industry, which can be attributed to the organic acids produced by these bacteria (Shaltout and Edris, 1999). (Lind *et al.*, 2005) tested the antifungal activities of various *Propionibacterium* strains against eight food- and foodborne mould and yeasts and found a significant reduction in the tested mould and yeast strains, especially with lower pH values due to the secreted propionic acid, with acetic acid being the most potent antifungal acid.

Propionibacterium spp., a cutting-edge probiotic, may be credited with improving the sensory qualities of the treated groups because they can use lactose and lactates as carbon sources, secret intracellular peptidases and cell wall associated proteases, synthesis compounds with preservatives properties (bacteriocins, propionic acid, and acetic acid), and they produce compounds with aroma and flavor. Furthermore, the recorded reduction in *C. albicans* can be referred to its ability to secrete bacteriocins, propanoic acid and vitamin B12 that have direct antifungal effects (Shaltout *et al.*, 2019b; Shaltout *et al.*, 2019a and Turgay *et al.*, 2020).

As acidifier, color diluent, curing and pickling agent, pH control agent, solvent, and preservative, acetic acid has been used in foods as a flavor enhancer and flavoring agent. It is generally recognized as safe when used in accordance with good manufacturing practice (FDA, 2012).

The obtained results came in agreement with those recorded by Northcutt *et al.* (2000), Serdaroğlu *et al.* (2007) and Shewail *et al.* (2018), who showed improvement in the sensory parameters of meat after the addition of acetic acid; while disagreeing with the results of Nadzirah *et al.* (2016) and Smith and Young (2007), who reported some changes in the color of the treated chicken meat.

Acetic acid is typically utilized as secure food preservative; they lower the cytoplasmic pH and halt metabolic activities. However, organic acids operate on the plasmic membrane to kill sensitive organisms by neutralizing its electrical potential and increasing its permeability (Dalie *et al.*, 2010 and Shaltout *et al.*, 2016). Some methods explain how organic acids' inhibitory mode causes pH to decrease, which may affect the development by acidifying the cell and requiring a lot of energy to maintain intracellular pH equilibrium (Pandey *et al.*, 2016). Other possibilities have also been put up, such as membrane disruption, metabolic processes being stopped, and the buildup of poisonous anions (Lind *et al.*, 2005). This hydrophobic property of the majority of organic acids, which permit unhindered transport of the protonized form across the cell membrane, was thought to be responsible for this phenomenon. The gradients in pH and osmolarity between the inner and outer surfaces of the cell cause this diffusion process to take place. The acid undergoes dissociation as soon as it enters the cytoplasm, which lowers the intracellular pH by releasing protons. The intracellular pH is greater than the external pH. The cell devotes most of its energy content to eliminate these newly produced protons to overcome the drop in cytoplasmic pH brought on by the ionization of the ingested acid, which causes slower growth kinetics (Pelaez *et al.*, 2012).

The obtained inhibitory effects of Propionibacterium and acetic acid on *C. albicans* came in agreement with El-Shafei *et al.* (2008), who reported that the potential of the tested *Propionibacterium* protective cultures to inhibit yeast growth on Kareish cheese (soft cheese) was a promising finding to be used in further processed food industries. While, Hassan *et al.* (2015) who examined the antifungal effects of many organic acids at different fungal growth and with variable concentration and detected that acetic acid (10%) has the highest inhibitory effect on the examined strains (45.21%) where the final pH was 3.25; Osman (2016) who recorded a significant improvement in the sensory quality with a significant reduction in yeast counts after 21 days of cold storage in chicken fillet after acetic acid treatment; Saleh *et al.* (2021) who recorded a significant reduction in the yeast count after treating with acetic acid in fresh meat. In addition, Pelaez *et al.* (2012) determined that the increase of acid in the medium decreases the growth rate and extends the lag phase of the tested microorganisms.

5. CONCLUSION

It can be suggested that the use of *Propionibacterium* and acetic acid as preservatives for the chicken fillet, helps in increasing its shelf life over a wide range of time.

6. REFERENCES

1. Abdelrahman, H.A., El-Ghayati, S. and Shaheen, H. (2020). Quality assessment of emulsion type poultry meat products. SCVMJ, 25(1): 129-141 **.**
2. Argañaraz-Martínez, E., Babot, J.D., Apella, M.C. and Chaia, A.P. (2013). Physiological and functional characteristics of Propionibacterium strains of the poultry microbiota and relevance for the development of probiotic products. Science Direct, 23: 27-37 **.**
3. Berge, P., Ertbjerg, P., Larsen, L.M., Astruc, T., Vignon, X. and Møller, A.J. (2001). Tenderization of beef by lactic acid injected at different times post mortem. Meat Sci., 57(4): 347-357 **.**
4. Blasco, L., Kahala, M., Jatila, H. and Joutsjoki, V. (2015). Application of 16S-ARDRA and RFLP-PFGE for improved genotypic characterisation of dairy propionibacteria and combination with characteristic phenotypes. Int. Dairy J., 50: 66-71 **.**
5. Collins, D.S. and Huey, R.J. (2015). Gracey's Meat Hygiene: Wiley-Blackwell**.**
6. Dalie, D.K.D., Deschamps, A.M. and Forget, F.R. (2010). Lactic acid bacteria – potential for control of mold growth and mycotoxins: A review. Food Control 21: 370-380 **.**
7. El-Shafei, K., Abd El-Gawad, M. A., Dabiza, N., Sharaf, O.M. and Effat, B.A. (2008). A mixed culture of Propionibacterium thoenii P-127, Lactobacillus rhamnosus and Lactobacillus plantarum as protective cultures in kareish cheese. Polish J. Food Nutr. Sci., 58(4): 433-441 **.**

8. FDA 2012. "21CFR184.1005." Web. 17 Apr. 2012. http://www.accessdata.fda.gov/scripts/cdrh/cfdocs/cfcfr/CFRSearch.cfm?fr=184.1005 .
9. Feldman, D., Ganon, J., Haffman, R. and Simpson, J. (2003). The solution for data analysis and presentation graphics.
10. Hassan, R., El-Kadi, S. and Sand, M. (2015). Effect of some organic acids on some fungal growth and their toxins production. Int. J. Adv. Biol. (IJAB), 2(1): 1-11 .
11. ISO (2008). International Organization for Standardization. No.21527-1. Microbiology of food and animal feeding stuffs — Horizontal method for the enumeration of yeasts and moulds — Part 1: Colony count technique in products with water activity greater than 0,95 .
12. ISO (2017). International Organization for Standardization. No.6887-2. Microbiology of the food chain — Preparation of test samples, initial suspension and decimal dilutions for microbiological examination — Part 2: Specific rules for the preparation of meat and meat products .
13. Kerry, R.G., Patra, J.K., Gouda, S., Park, Y., Shin, H. and Das, G. (2018). Benefaction of probiotics for human health: A review. J. Food and Drug Analysis, 23(3): 927-939 .
14. Lianou, A., Panagou, E.Z. and Nychas, G. (2017). Meat safety- Foodborne pathogens and other biological issues. Lawrie´s Meat Sci., 521–552. https://doi.org/510.1016/B1978-1010-1008-100694-100698.100017-100690 .
15. Lind, H., Jonsson, H. and Schnürer, J. (2005). Antifungal effect of dairy propionibacteria-contribution of organic acids. Int. J. Food Microbiol., 98(2): 157-165 .
16. Mahmoud, R., Alsadi, I. and Saleh, A. (2020). Assessment of microbiological quality of imported broiler chicken carcasses retailed for sale in Al Beida City, Libya. Damanhour J. Vet. Sci. 4(2): 16-19 .
17. Nadzirah, K. Z., Zainal, S., Noriham, A. and Normah, I. (2016). Application of bromelain powder produced from pineapple crowns in tenderizing beef round cuts. Int. Food Res. J., 23(4): 1590-1599 .
18. Nair, D.V.T., Thomas, V.J., Dewi, G., Noll, S., Brannon, J. and Johny, K.A. (2019). Reduction of multidrug resistant Salmonella enterica serovar Heidelberg using a dairy originated probiotic bacterium, Propionibacterium freudenreichii freudenreichii B3523, in growing Turkeys. J. Appl. Poultry Res., 28(2): 356–363. https://doi.org/310.3382/ japr/pfy3079 .
19. Nkosi, D.V., Bekker, J.L. and Hoffman, L.C. (2021). The use of organic acids (Lactic and Acetic) as a microbial decontaminant during the slaughter of meat animal species: A review. Foods, 10: 2293-2310 .
20. Northcutt, J.K., Smith, D.P. and Buhr, R.J. (2000). Effects of bruising and marination on broiler breast fillet surface appearance and cook yield. J. Appl. Poultry Res., 9(1): 21-38 .
21. Osman, L. (2016). The effect of acetic acid treatment on some quality properties of chicken breast during refrigeration. Food Technol., Thesis, Master Degree, Sudan Univ. of Sci. and Technology.
22. Pal, M. (1997). Use of Pal's sunflower seed medium for an early diagnosis of cryptococcosis. The Antiseptic, 95: 175.
23. Pal, M. (2007). Zoonoses. Second edition. Satyam Publishers, Jaipur, India.Pp. 179-180.
24. Pal, M. (2014). Emerging role of fungi in human and animal health. MSc. Lecture Notes. Addis Ababa University, College of Veterinary Medicine, Debre Zeit, Ethiopia. Pp.1-34 .
25. Pandey, R., Vischer, N.O., Smelt, J.P., van Beilen, J.W., Ter Beek, A., De Vos, W.H., Brul, S. and Manders, E.M. (2016). Intracellular pH response to weak acid stress in individual vegetative Bacillus subtilis cells. Appl. Environ. Microbiol., 82(21): 6463–6471. https://doi.org/6410.1128/AEM.02063-02016 .
26. Pelaez, A.M.L., Catano, C.A.S., Yepes, E.A.Q., Villarroel, R.R.G., Antoni, G.L.D. and Giannuzzi, L. (2012). Inhibitory activity of lactic and acetic acid on Aspergillus flavus growth for food preservation. Food Control, 24: 177-183 .
27. Saleh, A. A. (2014). Effect of feeding mixture of Aspergillus probiotic and selenium nano-particles on growth, nutrient digestibilities, selected blood parameters and muscle fatty acid profile in broiler chickens. Anim. Sci. Pap. Rep., 32: 65-79 .
28. Saleh, E., Shaltout, F. and Abd Elaal, E. (2021). Effect of some organic acids on microbial quality of dressed cattle carcasses in Damietta abattoirs, Egypt. Damanhour J. Vet. Sci., 5(2): 17-20 .
29. Serdaroğlu, M., Abdraimov, K. and Oenenc, A. (2007). The effects of marinating with citric acid solutions and grapefruit juice on cooking and eating quality of turkey breast. J. Muscle Foods, 18(2): 162-172 .
30. Shaltout, F.A., El-diasty, E.M., Salem, R.M. and Hassan-Asmaa, M.A. (2016). Mycological quality of chicken carcasses and extending shelf -life by using preservatives at refrigerated storage. Vet. Med. J. – Giza, 62(3): 1-10 .
31. Shaltout, F.A., Nasief, M.Z., Lotfy, L.M. and Gamil, B.T. (2019b). Microbiological status of chicken cuts and its products. Benha Vet. Med. J. 37(1): 57-63 .
32. Shaltout, F.A., Salem, R.M., El-Diasty, E.M. and Hassan, W.I.M. (2019a). Effect of Lemon fruits and turmeric extracts on fungal pathogens in refrigerated chicken fillet meat. Global Veterinaria 23(3): 156-160 .
33. Shaltout, F.A. (2002). Microbiological aspect of semi-cooked chicken meat products. Benha Vet. Med. J. 13(2): 15-26 .
34. Shaltout, F.A. (2022). Effect of monosodium glutamate substitutes on physiochemical, microbiological and sensory properties of fried chicken breast strips. Biomed. J. Sci. Tech. Res. 42(4): 33753- 33761 .
35. Shaltout, F.A. and Edris, A.M. (1999). Contamination of shawerma with pathogenic yeast. Assiut Vet. Med. J., 41(81): 170-176 .
36. Shewail, A., Shaltout, F.A. and Thabet, M.G. (2018). Impact of organic acids and their salts on microbial quality and shelf life of beef meat. Assiut Vet. Med. J., 64(159): 164-177 .
37. Smith, D.P. and Young, L.L. (2007). Marination pressure and phosphate effects on broiler breast fillet

yield, tenderness, and color. Poultry Sci., 86(12): 2666-2670 .

38. Turgay, M., Bachmann, H.P., Irmler, S., Ah, U., Fröhlich-Wyder, M.T., Falentin, H., Deutsch, S.M., Jan, G. and Thierry, A. (2020). Propionibacterium spp. and AcidiPropionibacterium spp. In: Reference module in food science, ed. G. Smithers: Elsevier. https://doi.org/10.1016/B978-0-08-100596-5.23016-3.
39. Ursachi, C.Ș., Perța-Crișan, S. and Munteanu, F.D. (2020). Strategies to improve meat products' quality. Foods (Basel, Switzerland) 9(12): 1883. https://doi.org/1810.3390/foods9121883.