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## Original Article

# Determination of mycotoxins level in poultry feeds at Dhamar Governorate, Yemen

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## KEYWORDS

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## ABSTRACT

Mycotoxins contamination in feed is a global safety concern. It induces significant economic losses to the poultry industry and poses substantial hazards to human health. The present study aimed to determine the levels of mycotoxin contamination in formulated and raw materials feeds used to grow broilers chicken in Dhamar Governorate, Yemen. A total of 36 samples were randomly collected from variety types of poultry feed used in poultry farms at Dhamar governorate. Methanol was used as organic solvents for mycotoxin extraction from solid feed samples. Quantitative, rapid ELISA test kits were used to detect levels of mycotoxins. The results revealed that, Aflatoxins, T-2 toxins, Ochratoxins A, and Zearalenone were detected in 36.11%, 83.33%, 22.22%, and 100% of the tested samples, with contamination levels of 0.37, 21.67, 0.8, and 14.04 ppb, respectively. The highest levels of aflatoxins and Ochratoxins were found in Ordinary Feed-I (1.00 and 3.47 ppb) and Ordinary feed-II (1.07 and 4.9 ppb) respectively. Similarly, the highest level of Zearalenone was detected in Ordinary feed-I (19.87 ppb). The highest levels of T-2 toxin were detected in the Primitive concentrate (49.23 ppb) and Final Concentrate (49.47 ppb). Mycotoxins were detected at relatively lower levels in the other feed types tested. Statistical analysis showed a significant difference ( $P$  value < 0.05) in mycotoxin levels between feed types. Ordinary Feeds were more contaminated compared to raw ingredient feeds. These findings highlight the threat posed by mycotoxins to poultry and public health in Dhamar governorate and point to the need to implement intervention measures to reduce these risks. Further studies are required to determine the factors associated with mycotoxins contamination in poultry feeds.

## INTRODUCTION

Mycotoxins, a diverse group of toxic secondary metabolites produced by filamentous fungi, pose detrimental effects on human and animal health. These toxins can enter human and animal bodies either directly, through contaminating Agricultural products or ready-to-eat items, or indirectly, through the consumption of products derived from animals and poultry feed on contaminated materials (Adanyi et al., 2018). Mycotoxins produce a variety of diseases, collectively called "mycotoxicoses," directly or in combination with other primary stressors such as pathogens (Raju and Devegowda, 2000). These diseases are exhibited by symptoms and lesions, which can be used to clinically diagnose the presence of mycotoxins although these symptoms are not just straightforward. When Aflatoxins (AF) and Ochratoxins (OTs) are co-

contaminants of poultry feed, they interact in a synergistic manner. When AF and T-2 toxin are co-contaminants of poultry feed, the T-2 toxin prevent the major effects of AF. This reduces the ability to diagnose aflatoxicosis in the field (Huff et al., 1988).

Recent literature has implicated physiological and immunological effects of mycotoxins at lower and more common levels of contamination. As many of the mycotoxins and their metabolites inhibit protein synthesis, tissues with high levels of protein synthesis and turnover, such as those within the gastrointestinal tract (GIT) can be particularly susceptible to their toxic effects. In particular, the GIT is repeatedly exposed to mycotoxins at concentrations likely higher than other organ systems (Grenier and Osoald. 2011). However, it has been clearly demonstrated that some cells of poultry bodies (such as immune, intestinal, and hepatic cells) are predominantly affected by mycotoxins

(Grenier and Applegate, 2013).

Mycotoxins do not possess immunogenic properties, meaning they are not able to induce an immune response unlike pathogens. But they do interfere with the signaling pathways that are responsible for cell growth or death (apoptosis) (Murugesan et al., 2015). Mycotoxins are typically produced by filamentous fungi, especially those belonging to the genera *Aspergillus*, *Penicillium*, *Alternaria*, *Fusarium*, and *Claviceps spp*, which are the main producers of mycotoxins (Sforza et al., 2006).

Approximately 300 to 400 mycotoxins have been identified and reported so far by the Council for Agricultural Science and Technology and others (CAST, 2003; Schollenberger et al., 2007; Pinotti et al., 2016). While hundreds of mycotoxins have been identified, only a few, including Aflatoxins (AFs), Fumonisin (FMs), Ochratoxins (OTs), Trichothecenes (TRCs), and Zearalenone (ZEN), are considered major safety and economic concerns (FAO and WHO., 2007; Smith et al., 2016; Santos et al., 2019). T-2 toxin is the most toxic fungal secondary metabolite produced by different *Fusarium spp*, (Chen et al., 2020). Moreover, T-2 is the most common cause of poisoning that results from the consumption of contaminated cereal-based food and feed reported among humans and animals (Milicevic et al., 2010). T-2 toxin was identified as a significant threat to human and animal health (Nayakwadi et al., 2020). T-2 has different toxic effects depending on the dosage, age, and ways of exposure (oral, dermal, and aerosol).

Generally, observed acute toxicological effects are feed refusal, vomiting, hemorrhages, stomach necrosis, and dermatitis (Garai et al., 2020). Aflatoxins, in particular, are notorious for their carcinogenic properties and are classified as human carcinogens (group I) by the International Agency for Research on Cancer (IARC, 2012). It is produced by *Aspergillus spp*. and includes four forms: AFB1, AFB2, AFG1, and AFG2 (Awika, 2011). Similarly, OTs, FMs, and Sterigmatocystin have been classified as possible human carcinogens in Group 2B (IARC, 1994). On the other hand, some mycotoxins, such as Zearalenone, exhibit estrogenic activity, leading to hyperestrogenism, sterility, and abortions in affected animals (da Rocha et al., 2014). Although not very prevalent, HT-2 and T-2 toxins are the most toxic TRCs (Streit et al., 2012; Groopman et al., 2013; Marin et al., 2013; Kovalsky et al., 2016). Where they are linked to specific syndromes in farm livestock

and poultry (Caloni and Cortinovis., 2010).

In livestock and poultry, the consumption of mycotoxin-contaminated feed results in substantial economic losses, manifesting as impaired growth, decreased productivity, and compromised reproductive efficiency. It causes liver and kidney damage and immunosuppression (Bentvihok et al., 2002; Richard, 2007; Marroquin-Cardona et al 2014). Moreover, simultaneous exposure to multiple mycotoxins can lead to synergistic effects, exacerbating the negative impacts on animal performance and health (Streit et al., 2013).

Consequently, regulatory bodies worldwide have established permissible limits for mycotoxin levels in feed to mitigate these risks (FAO, 2004). For instance, the maximum permitted levels according to the European Union (EU) regulations are 5-20 µg/kg for AFB1, 100–500 µg/kg for zearalenone, and 50–100 µg/kg for OTs, depending on the feed materials (ECCR, 2006). Despite the regulatory measures in place, studies have highlighted the pervasive presence of mycotoxins in poultry feed and its raw ingredients, with some samples exceeding permissible limits (Kosicki et al., 2016; Arroyo-Manzanares et al., 2019). Therefore, continuous monitoring and control of mycotoxin contamination in animal feed are imperative to safeguard animal and human health and maintain low toxin levels in the food chain (EUC, 2015).

In Yemen, data on mycotoxin contamination of poultry feeds are scarce. A study published in 2018 assessed mycotoxin levels in poultry rations from four governorates in Yemen, including Sana'a, Taiz, Ibb, and Dhamar. The highest contamination with aflatoxins (42.5 ppb) was found in rations from Taiz and Dhamar. The study highlights significant fungal contamination and mycotoxin levels in poultry feed, which could impact the poultry industry economically in Yemen (Algabr et al., 2018). In 2022, the poultry sector in Yemen faced significant obstacles, with data indicating a negative growth rate (FAOSTAT, 2024), largely due to exposure to infections and mycotoxins (Anonymous, 2022). This study aimed to assess the contamination levels of mycotoxins in broiler poultry feed and its raw materials in Dhamar Governorate, Yemen.

## MATERIALS AND METHODS

### Study area and Sampling

This study was conducted in Dhamar Governorate; Samples were collected at the end of the summer season in 2023. Thirty-six feed samples were randomly collected from twelve types of poultry feed and raw materials used in different broiler rearing stages. 100g

were collected for each sample. These samples were gathered from feed manufacturing companies and feed stores in poultry farms of Dhamar Governorate. The feed samples represented four poultry feed categories including: Starter feed, grower feed, finisher feed and raw materials. All the samples were collected with a sterile spoon, placed inside sterile plastic bags, and labeled with the necessary information data. Samples were then stored at 4°C until sent to the laboratory for mycotoxins analysis. The first group of feed samples from 1- 9 were contain Soybean, Corn, Broiler concentrate and supplementation with different concentrations; Whereas; the second group of feed samples from 10- 12 were contain yellow corn, white corn and soy-bean as presented in Table 1.

### Laboratory analysis and quantification of mycotoxins

The mycotoxin content or level in the feeds was determined by the ToxinFast® ELISA kit (Meizheng Bio-Tech Company, Beijing, China). Four ELISA test kits were used to determine levels of the mycotoxin in poultry feeds. The test was performed at the laboratory of Al-Sanabany Company, Sana'a, Yemen. The test was performed following the manufacturer's instructions. Briefly, samples of raw materials were ground. Mycotoxins were extracted from each sample using the following procedure: 20g of each sample was mixed with 100 ml of 70% methanol solvent (ratio 1:5 w/v) in sterile tubes. The mixture was shaken, centrifuged, and then filtrated with filter paper. Filtrates were collected in sterile tubes and diluted in deionized water at a ratio of 1:1 v/v). The extracted, filtered samples were cleaned by add deionized water. Diluted filtrates samples were run in ELISA in triplicate, and placed in a microwell strip holder (ELISA microplate) to tested with the ELISA test kits as indicated by the manufacturer instructions. The optical density/absorbance value (OD) was measured at 450 nm by ELISA spectrophotometer. The amount of mycotoxins in the feeds samples were calculates automatically by Microwell Reader (NEOGEN® Stat-Fax 4700, SKU No. 9303. USA).

### Statistical analysis

Microsoft Excel was used for data manipulation. A two-way ANOVA was used to determine descriptive statistics, interaction, and generation of graphics using Graph Pad Prism 8.4.2 software. Results were presented as mean  $\pm$  SD. A *P*

value of <0.05 was used as a statistically significant difference.

### RESULTS

The contamination level of mycotoxins in poultry feeds in Dhamar governorate are presented in Figure 1. As shown, four toxins were identified, namely, Aflatoxins, T-2 toxins, Ochratoxins, and Zearalenone. The levels of contamination with these mycotoxins were 0.37, 21.67, 0.8, and 14.04 ppb respectively.

**Aflatoxins** were present in 36.11% of the tested samples. The highest level of aflatoxins. contamination was in Ordinary Feed-I one and Ordinary feed-II, the mean aflatoxin level in parts per billion was highest was 1.00 and 1.07ppb respectively. Very low quantities of aflatoxins with mean range between 0.33 to 0.73ppb were also detected in Levantine corn, Soya bean, Final non-granular, Primitive concentrate, and Final concentrate. Other feed varieties, including Primitive granular, Final granular, Primitive local feed, White corn, and Primitive non-granular, do not contain any measurable quantities of aflatoxins.

**T-2 toxin** was present in 83.33% of the tested samples. The mean of T-2 toxin levels in the Primitive concentrate and Final concentrate were the highest, with mean values as 49.23 and 49.47ppb respectively. The feed samples labeled "Ordinary feed-I, "Primitive local feed", "Soya bean," "Final granular," and "Levantine corn" exhibited notable amounts of **T-2 toxin with mean value as 19.1-22.5 ppb**. The amounts of **T-2 toxin** in Ordinary feed-II (a grower mash feed II - Soybean, Corn, Broiler concentrate and Supplementation), Primitive granular, Final non-granular, and Primitive non-granular are rather low, ranging between 10.67 to 15.20 ppb. however, white corn was not contaminated with T-2 toxins.

**Ochratoxins** were detected in 22.22% of the tested samples. Only Ordinary feed-I and Ordinary feed-II were exhibited low quantities of Ochratoxin, with mean concentration value as 3.47 and 4.9 ppb), respectively.

**Zearalenone** was detected in all the tested samples. The zearalenone contamination level in Ordinary feed-I (a grower mash feed. I - Soybean, Corn, Broiler concentrate and Supplementation) was the highest, with mean value as 19.87 ppb, whereas; notable amounts of zearalenone were detected in Primitive granular, Final granular, Primitive local feed, Soya bean, Final non-granular, and Primitive non-granular, with range values between 13.3 to 16.1ppb. Furthermore,

the results of this study revealed that, the samples of White corn, Primitive concentrate, Final concentrate, and Levantine corn exhibited the low amount of contamination with means ranging between 10.5 to 12.4 ppb.

The statistical analysis of the present study findings revealed notable differences in the levels of contamination among various feed types and different mycotoxins types as depicted in Table 2. The tested 12 feed types showed a significant difference in mycotoxin contamination (F value = 19.58 and P value < 0.0001). The type of feed accounts for 9.135% of the total variance. On the

other hand, the type of the mycotoxin (n = 4) showed a significant difference in their distribution among feed types (F value = 467.0 and P value < 0.0001). The type of mycotoxin was the main factor affecting variance, where it accounts for 59.41% of the total variance. Additionally, there was a significant interaction between the types of feed and the types of mycotoxins (F value = 19.57 and P value < 0.0001), implying that the impact of feed type on the levels of mycotoxins contamination differs depending on the specific type of mycotoxins. The interaction accounts for 27.39% of the total variance.

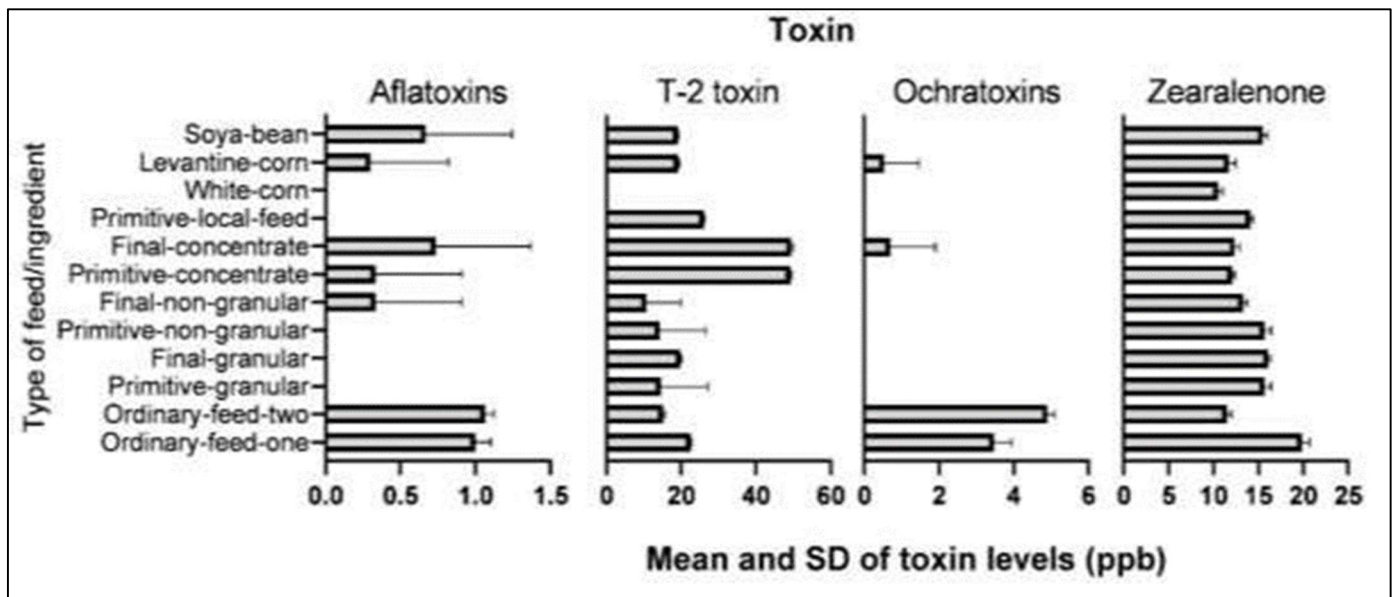


Figure 1. Contamination level (ppb) of mycotoxins in poultry feed and raw materials used on growing broilers in Dhamar governorate

Table 1. Type, Categories and composition of poultry feed tested in this study

NO.	Feed`s type	Categories	Cp(%) & Me(K/Kg)	Age of chicks
1	Primitive concentrate	A starter concentrate feed	CP 44,0 , ME 2230	1-3 weeks
2	Primitive local feed	A locally starter feed	CP 8.9, ME 3350	1-3 weeks
3	Primitive granular	A starter pelleted feed	CP 9.0, ME 3350	1-3 weeks
4	Primitive non granular	A starter mash feed	CP 22.8, ME 3150	1-3 weeks
5	Final non granular	A grower mash feed.	CP 18.3, ME3250	3-6 weeks
6	Ordinary feed -I	A grower mash feed. I	CP 23.0, ME 3180	3-6 weeks
7	Ordinary feed -II	A grower mash feed. II	CP 18.5, ME3260	3-6 weeks
8	Final granular	A finisher pelleted feed	CP 23.2, ME 3230	6wk upwards
9	Final concentrate	A finisher concentrate feed	CP 17.9, ME 3155	6wk upwards
10	Levantine corn	Feed raw material	CP 23.4, ME 3320	All ages
11	White corn	Feed raw material	CP 20.2, ME 3205	All ages
12	Soy-bean	Feed raw material	CP 20.0, ME 3200	All ages

CP = crude protein (%), ME = metabolizable energy (K Calorie/Kg), Wk= Week

**Table 2. Results of the two-way ANOVA analysis on contamination level of Mycotoxins in different Poultry Feeds tested**

Sources of variation	SS	DF	MS	F (DFn, DFd)	P value	Attributed Variance %
Interaction	5435	33	164.7	F (33, 96) = 19.57	P<0.0001	27.39%
Type of feed	1813	11	164.8	F (11, 96) = 19.58	P<0.0001	9.135%
Type of mycotoxin	11790	3	3930	F (3, 96) = 467.0	P<0.0001	59.41%
Residual	807.9	96	8.416			

SS= Sum of Square DF= Degree of Freedom MS= Mean Squares F= F value

## DISCUSSION

The poultry sector is a vital sector in the Yemeni economy (UNDP, 2020), and it has experienced challenges in the past few years, including broiler poultry in Dhamar Governorate. The country's annual poultry production (live birds) in the year 2022 dropped by 1.91% compared to the year 2021 (FAOSTAT, 2024). Non-compliance with vaccination programs and inappropriate storage of poultry feeds were accused for exposure to infections and mycotoxins (Anonymous, 2022).

In this study, the contamination level of feed samples with aflatoxins and T-2 toxins were as follows: (0.37 and 21.67 ppb), respectively. The levels were below than the levels established by the safe feeding levels for mycotoxins in poultry feed, the recommendations of European Community concerning complete feeding stuffs and European Union regulatory levels (a) and established guidelines (b) on mycotoxins in feed stuffs for broilers i.e 20 and 250 ppb (ECCR, 2006; ECCR, 2013). The mean concentration levels of contamination of feed samples with Ochratoxins was as 0.8 ppb; this level also was below than level established by the safe feeding levels for mycotoxins in poultry feed, the recommendations of Food and Agriculture Organization, the acceptable recommended level is 100 ppb (FAO, 2004). Moreover, the results of this study also displayed that, the mean concentration of zearalenone in feed samples was 14.04 ppb, these findings are lower than level established by the safe feeding levels for mycotoxins in broilers and recommendations used by the OISC i.e. 500 ppb (MPFC, 2011; ECCR, 2006). The results of present study on aflatoxins levels in poultry feeds are in agreements with findings of previous

reports studies in Dhamar governorate (Algabr et al., 2018).

The contamination of the food and feed ingredients with aflatoxins in current study was in line with several previous reports on aflatoxin contamination of cereals, nuts, legumes, oilseeds, and their products (Ezekiel et al., 2012; Ezekiel et al., 2013; Adetunji et al., 2014; Egbontan et al., 2017; Oyedele et al., 2017;). The most frequently found toxin in soybeans was aflatoxins, which are produced by *Aspergillus spp.* Similarly, High level of aflatoxins was reported from other countries, including Cameroon, India, Nigeria, South Africa and Cuba (Oluwafemi et al., 2009; Njobeh et al., 2012; Abia et al., 2013; Kehinde et al., 2014; Kotinagu et al., 2015; Ochieng et al., 2021). For example, the aflatoxins level in poultry feed reported from Nigeria and Cuba were 198 ppb and 5.0 ppb (Escobar and Regueiro, 2002) respectively.

In present study, the aflatoxins concentration in poultry feed was 0.37ppb, these findings are higher than that reported in broiler feed (0.104 ppb) from the Czech Republic (Mikula et al., 2020) and lower than findings reported from Pakistan i.e. 5 to 89.9 ppb by Fareed et al., (2014). The concentration of Ochratoxins was 0.8 ppb, these results are higher than (0.380 ppb) reported from the Czech Republic (Mikula et al., 2020) and lower than findings reported from Pakistan (22.5 to 85ppb) by Sherazi et al., (2015). In Serbia, Krnjaja et al., (2014) reported the Ochratoxins in chicken feeds as 34.4 ppb, and in laying hen feeds as 43.89 ppb. The concentrations of T-2 toxins and zearalenone were as 21.67 and 14.04 ppb respectively, these results are lower than findings of Mikula et al. (2020) who reported the level of

contamination as 40 and 343 ppb respectively in Czech Republic.

The discrepancy in mycotoxins contamination level in poultry feeds reported among above studies and present study could be attributed to several of factors such as: climatic factors, agricultural, processing practices (handling and storage) of raw materials and formulation utilized during the compounding of the feed (Gutleb et al., 2015). Moreover, many workers (CAST, 2003; Golob, 2007; Dagher, 2008; Waliyar et al., 2009; Köppen et al., 2010; Schmidt-Heydt et al., 2011; Rodriguez-Carrasco et al., 2013; Dzuman *et al.*, 2014; Pereira *et al.*, 2014; Xie *et al.*, 2016; Smith et al., 2016; Anfossi *et al.*, 2016; Marroquín-Cardona et al., 2014; Garbaba et al. 2018) suggested that, the occurrence of mycotoxins varies with seasons, poor storage (the main factor that may encourage fungal growth and mycotoxin production for both local and imported poultry feeds), environmental and weather factors such as temperature, rain, PH and analysis techniques or assay for determination of mycotoxins. Furthermore, It has been reported that poultry feed components, primarily imported to Yemen from abroad, that may could be carried mycotoxins contamination from their origin to country (Algabr et al., 2018).

## CONCLUSIONS

The present results showed that all feed types and raw ingredients tested contained relatively low levels, and there were differences in the level and types of mycotoxins between the feed manufacturing companies, with the exception of zearalenone, which is found in all types of feed and exceeds the permitted limit. The co-occurrence of multiple mycotoxins may enhance overall toxicity due to synergistic effects, reduce profitability for farmers, and possibly affect final consumers. There is a need to minimize mycotoxin contamination in broiler feeds, these may be adapted through the proper storage of feeds and ingredients, regular monitoring of mycotoxins in poultry feeds, implementing good agricultural practices, and exploring less contaminated crop alternatives.

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## CONTRIBUTION OF AUTHORS

HAG designed the study, conducted experiments, wrote the manuscript. Authors, AAA, FAB and SMAA, collection and contributed in testing of specimen and analysis of data. All authors have seen and approved this version of the manuscript.

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The authors received no direct funding for this research.

## COMPETING INTERESTS

The authors declare no competing interests.

## DATA AVAILABILITY

All data generated and analyzed during this study are included in this published article.

## ETHICS CONSIDERATIONS & Approval

The study was approved by Faculty of Veterinary Medicine, Tamar University, Yemen.

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## تحديد مدى تلوث أعلاف الدواجن بالسموم الفطرية في محافظة ذمار، اليمن

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### الملخص

يعد تلوث أعلاف الدواجن بالسموم الفطرية مصدر قلق عالمي للصحة العامة، إذا إنه يتسبب في خسائر اقتصادية كبيرة في صناعة الدواجن، ويشكل مخاطر كبيرة على صحة الإنسان. هدفت الدراسة الحالية إلى تحديد مستويات التلوث بالسموم الفطرية في الأعلاف المصنعة والمواد الخام المستخدمة في تربية الدجاج اللحم في محافظة ذمار، اليمن. تم جمع ما مجموعه 36 عينة عشوائية من أنواع مختلفة من أعلاف الدواجن المستخدمة في مزارع الدواجن في محافظة ذمار. تم استخدام الميثانول كمذيب عضوي لاستخلاص السموم الفطرية من عينات الأعلاف المستهدفة في الدراسة. تم استخدام اختبارات وتقنية ELIZA للكشف عن مستويات السموم الفطرية العلائق/ الاعلاف المستهدفة. تم التعرف على اربعة سموم فطرية هي: Aflatoxins, T-2 toxins, Ochratoxins A, and Zeralenone بنسبة 36.11% و 83.33% و 22.22% و 100% من العينات المفحوصة، وكانت متوسطات مستويات التلوث بالسموم المذكورة هي: 0.37 و 21.67 و 0.8 و 14.04 جزء في البليون على التوالي. كشفت النتائج أيضا ان أعلى مستويات aflatoxins and Ochratoxins كانت في العلف I-Ordinary feed (1.00 و 3.47 جزء في البليون) والأعلاف II-Ordinary feed (1.07 و 4.9 جزء في البليون) على التوالي. وبالمثل، كانت عن أعلى مستوى Zearalenone في العليقة I-Ordinary feed (19.87 جزء في البليون). كما وأوضحت النتائج ان أعلى مستويات T-2 toxin في العليقة المركزة البادئة 49.23 (جزء في البليون) و العليقة المركزة النهائية (49.47 جزء في البليون). بينما كانت مستويات التلوث أقل نسبيا في أنواع الأعلاف الأخرى التي تم اختبارها. أظهر التحليل الإحصائي ان هناك فروقا معنوية ذات دلالة احصائية ( $P < 0.05$ ) بين متوسطات و مستويات السموم الفطرية في أنواع الأعلاف التي تم دراستها. كانت الأعلاف العادية أكثر تلوثا مقارنة بأعلاف ذات المكونات الخامة. سلطت النتائج هذه الدراسة الضوء على التهديد الذي تشكله السموم الفطرية على الدواجن والصحة العامة في محافظة ذمار واكشفت عن ضرورة اتخاذ التدابير الخاصة للحد من هذه المخاطر. كما واوصت بأجراء المزيد من الدراسات لتحديد العوامل المرتبطة بتلوث السموم الفطرية في أعلاف الدواجن.

**الكلمات المفتاحية:** أعلاف الدواجن، السموم الفطرية، الإليزا، تحديد، محافظة ذمار، اليمن.

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## Original Article

# Bacterial contamination of Yemeni currency papers and their antibiotic resistance patterns

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### ABSTRACT

This cross sectional study was carried out during 2020-2021 on Yemeni currency papers to determine the prevalence rate of bacterial contamination and associated risk factors. Anti-microbial sensitivity patterns of the common pathogens contaminated Yemeni currency papers were also investigated. A total of 324 currency papers were collected randomly from different areas of Dhamar city and examined. The samples were collected from different categories of community people such as health care workers, butcher's shops, vegetable vendors, restaurants waiters, public transport conductors, Berbers and Bankers. The currency papers were transferred to microbiology laboratory and tested for bacterial contamination using standard microbiological methods. Antibiotic resistance patterns of isolated bacteria were determined by disk diffusion method. The results revealed that, out of 324 samples examined, 315 samples were positive for bacterial contamination with overall prevalence rate as 97.22%. The results of bacterial culture revealed that, 14 bacterial species were identified. The species identified were *Escherichia coli* (*E. coli*) with the highest prevalence rate (23.81%) followed by *Citrobacter spp.* (18.73%), *Staphylococcus epidermidis* (14.6 %), *Klebsiella.* (9.52%), *Staphylococcus aureus* (8.57%), *Pseudomonas spp.* (6.03%), *Proteus spp.* (5.4%), *Shigella spp* (3.17%), *Streptococcus pyogens* (3.17%), *Salmonella spp* (2.86%), *Streptococcus pneumonia* (2.54%), *Enterobacter spp.* (0.95%) and *Enterococcus* (0.63%). There were significant differences ( $P < 0.05$ ) on the prevalence rates among isolates species. There were no association ( $P < 0.05$ ) between contamination rate of currency papers and source of samples. All isolated bacteria were resistant to Methicillin and Ceftazidime; whereas, sensitive to others antibiotics in particular Piperacillin/ Tazobactam. In conclusion, the Yemeni currency papers circulating among community people were contaminated with variety range of bacterial species and some of them multi-drug resistant to common antibiotics. The decontamination of currency paper with disinfections in the banks and markets is recommended to reduce the transmission of pathogens to human.

### INTRODUCTION

Microorganisms are present almost everywhere in our surroundings. They may propagate via food, water, air and most importantly by fomites (Barolia et al., 2011;

Ejaz et al., 2018; Abdul Kader and Al-Rawi, 2021). The environment plays an important role in transmission of microorganisms to humans and materials such as

currency papers/notes serve as vehicles for microbial transmission (Elumalai et al., 2012). Currency papers/notes are the most needed material by each and everybody in a civilized society to reach a socio-economical class of getting basic needs useful to human (Beattie, 2018). Currency note is widely exchanged for goods and services in the entire global economic environment, it has promoted trade in communities since its first introduction in China approximately 1,000AD (Ireland and Bernholz, 2003; Assayaghi et al., 2021).

People are aware about spread of pathogens through food, air, water and have taken enough steps to control it. However, Studies of the contamination of money with microbial agents are lacking in most countries of world. Shortage of information may contribute to the absence of public health policies regarding currency usage, handling, and circulation (Al-Ghamdi et al., 2011; Sucilathangam et al., 2016; Anuranjini et al., 2017).

Microbial contamination of currency paper could be occurred during the production process, storage, counting, and handling (Awodi and Nock, 2001; Thiruvengadam et al., 2014). Other, practices like wetting the fingers with saliva when counting the papers, scattering currency paper during the several events and ceremonies, keeping the papers in unclean pocket, dirty stockings, in time of animal slaughtering and food preparation (Ameh and Balogun, 1997; Ogo et al., 2004; Khalil et al., 2014). The contaminated papers go in circulation and spread contaminated microbes among the people. These ways of transmission are significance in public health community worldwide (Thiruvengadam et al., 2014). Currency papers play a significant role in transmission of infectious diseases such as trachoma, diphtheria, gastroenteritis, whooping cough, diarrhea and other diseases (Sharma and Dhanashree, 2011); and multidrug-resistant microorganisms (Gedik et al., 2013). Maintaining personal hygiene can help for reducing the presence of microbes on currency paper, thereby reducing the risk of transmission during currency exchange (Al-Hajj et al., 2024).

The quantity and quality of pathogens transfer by currency papers are influenced by many factors, for example; currency notes of lower denominations exhibit higher contamination level comparing to currency notes of higher denominations due to their

more rapid turnover. Bacterial contaminations also depends upon the age of currency and the materials used in the production of the currency notes (Basavarajappa et al., 2005; Vriesekoop et al., 2010; Firoozeh et al., 2017; Ejaz et al., 2018).

Considerable investigations in different geographical regions of the world have been conducted on microbial contamination of currency papers in circulation and reported variation rate of currency contamination (Thiruvengadam et al., 2014; Elsharief et al., 2018; Gedam et al., 2018; Usman et al., 2021; Ilyasu et al., 2021; Elleboudy et al., 2021; Cozorici et al., 2022); and in some governorates of Yemen (Hanash et al., 2016; Assayaghi et al., 2021; Al-Hajj et al., 2024). The bacterial species isolated and identified of above studies were *Escherichia coli*, *Salmonella spp.*, *Enterococci spp.*, *Klebsiella spp.*, *Shigella spp.*, *Mycobacterium tuberculosis*, *Vibrio cholera*, *Bacillus spp.*, *Staphylococcus spp.*, *Pseudomonas spp.*, and *Corynebacterium spp.*, *Aerobacter spp.*, *Mycobacterium tuberculosis* and *Streptococcus faecalis* (Kawo et al., 2009; Moosavy et al., 2013; Akond et al., 2015; Boidya et al., 2015; Hanash et al., 2015; Mbata et al., 2016; Firoozeh et al., 2017; 2018; Gedam et al., 2018; Obajuluwa et al., 2023). However, there are dearth of information on microbial contamination of Yemeni currency papers at Dhamar city. Therefore, the aim of the present study was to investigate the bacterial contaminants on majority denominations of Ryal notes in circulation at Dhamar city and their antibiotic resistance patterns.

## MATERIALS AND METHODS

### Study area

This study was conducted at Dhamar city, Dhamar governorate during 2020-2021. Geographically, Dhamar is located at 14°58'N latitude, 44° 43'E longitude and at an elevation of 2415.09 meters (7923.52 feet) above sea level, Dhamar has a Mid-latitude desert climate. The city's yearly temperature is 20.97°C (69.75°F) and it is -4.56% lower than Yemen's averages. Dhamar typically receives about 109.11 millimeters (4.3 inches) of precipitation and has 149.45 rainy days (40.95% of the time) annually (Anonymous, 2024).

### Study Samples

The study samples of this study were Yemeni currency papers with various denominations. The samples were

collected from different categories people of community working in hospitals, butchers` shops, vegetable vendors, restaurants, public transport, barber shops and banks at Dhamar city.

### Size of sample

The sample size was calculated according keys given by Allan et al. (2018) considering 30% expected prevalence and 95% confidence interval with a 5% desired absolute precision using the following formula:  $N = (Z)^2 P(1-P)/d^2$ , where, (p) expected prevalence and (Z) 95% confidence interval (Z= 1.96) and (d) a 5% desired absolute precision.  $N = 1.96^2 P_{exp} (1-P_{exp})/D^2$ : Where,  $P_{exp}$  = expected prevalence;  $d$  = absolute precision;  $n$  = sample size. A total of 323 currency papers were investigated in this study.

### Study design and sitting

This cross sectional study was carried out during years of 2020-2021 in laboratory, Department of Microbiology, Faculty of Medical Science, AlHikma, Dhamar, Yemen. A total of 323 Yemeni currency papers of various denominations (100, 250,500 and 1000 Ryials) were collected from different community people of the city, namely, health care workers, butchers, vegetable vendors, restaurants waiters, public transport conductors, Berbers and Bankers; whereas, the currency papers with denomination of 50 and 200 Ryials were excluded from study due to their less circulation in study areas. To collect the paper currency, the individuals were requested to drop currency papers into a sterile polythene bag and labelled accordingly; Papers/notes were not touched by the researcher using bare hands at any stage. The individuals were given a replacement note equivalent to the denomination they had deposited in the sampling bag. The bag was sealed and immediately transported to the laboratory for analysis (Sucilathangam et al., 2016; Usman et al. (2021).

### Isolation and Identification of bacteria isolates

In laboratory, isolation of bacterial species contaminated the currency paper was performed according the technique described by Cheesbrough (2000); Thiruvengadam et al. (2014) and Firoozeh et al., (2017). Briefly, a sterile cotton-tipped swab moistened with sterile physiological saline (0.85% NaCl) was used to swab both sides of the currency

paper. The swabs were directly inoculated on MacConkey agar and blood agar. The inoculated media were incubated aerobically at 35- 37°C for 24h and then examined for bacterial growth.

Identification of bacteria isolates was based on morphology characteristics, Gram reaction as well as biochemical techniques such as the Indole, Coagulase, Oxidase, Urease, Catalase test and Triple sugar iron tests (sugar fermentation and gas production) in pure culture according to protocols described previously by Cheesbrough (2000) and Leboffe and Pierce, 2011).

### Antimicrobial susceptibility test

Antimicrobial susceptibility test was performed according to keys given by Clinical and Laboratory Standards Institute (CLSI, 2014) and Ali et al. (2015). In brief, a standard bacterial suspension was prepared in sterile Mueller-Hinton broth with 8 hrs.' incubation at 37°C till its turbidity exceeds the standard McFarland tube No. 0.5. Then dipped sterile cotton swab into standard bacterial suspension and swab was used to streak entire surface of Mueller-Hinton agar by rotating clock wise and anti-clock. Then antibiotic disks were placed on the surface of inoculated plates by gentle pressing with sterile forceps to make sure the contact of disk with media plate surface. The plates were then incubated for overnight incubation at 37°C. Results for sensitivity were noted next day by measuring zone of inhibition with standard scale and interpreted the results according to guidelines given by CLSI (2014). The testes antibiotics were Cefuroxime (CXM), Piperacillin/Tazobactam (PTZ), Methicillin (MET), Amoxicillin (AX), Ampicillin (AS), Ceftazidime (CAZ), Penicillin G (P<sub>10</sub>), Doxycycline (DOX) and Vancomycin (VA).

### Data analysis

The collected raw data were organized and arranged using the Microsoft Excel spread sheet computer programme and analyzed using SPSS version 20 statistical software's. Chi-square tests was applied to test the statistical association exists among the variables, prevalence rate of bacterial infections. All results were considered statistically significant when the  $P$ -value <0.05.



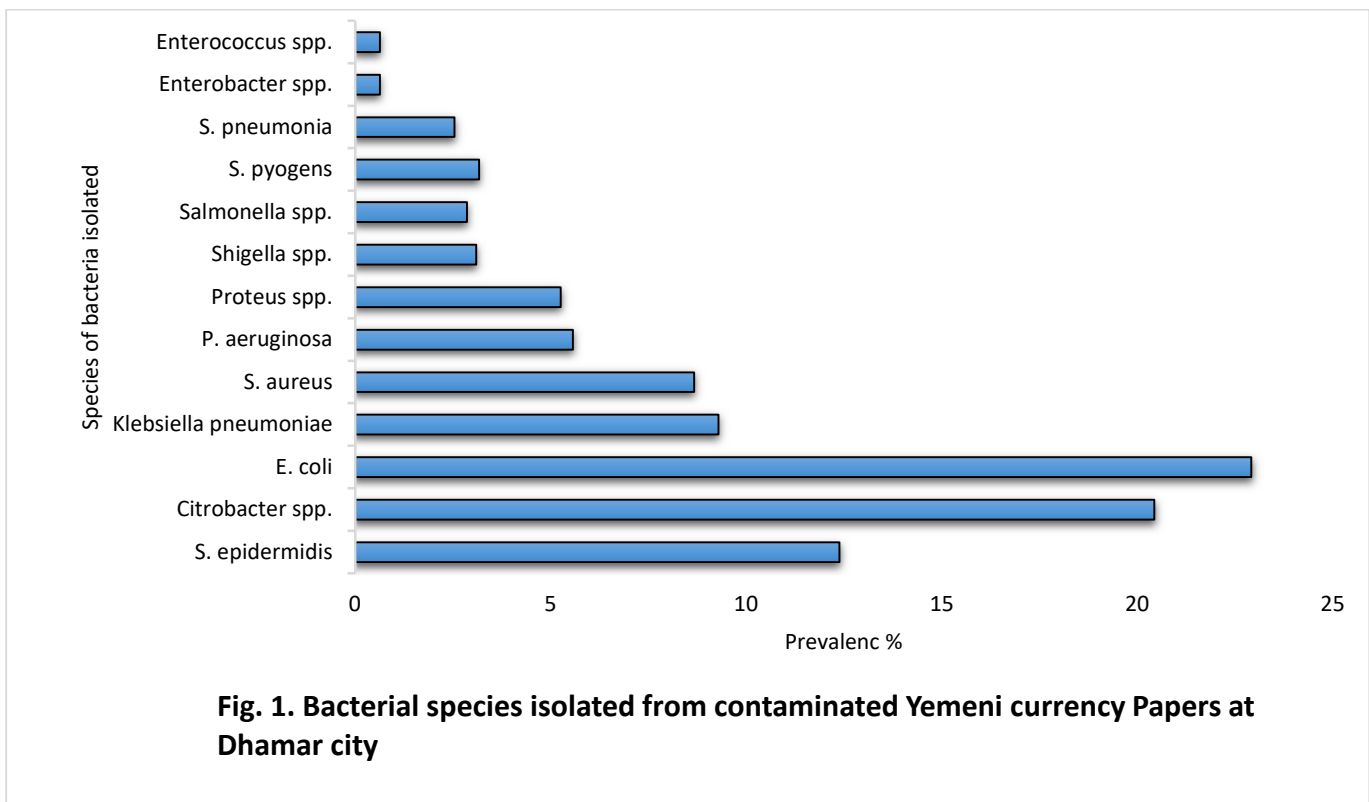
**RESULTS**

In this study, 323 Yemeni currency papers were collected and screened for bacterial contamination, 315 papers were found positive for one or more bacterial species with overall prevalence rate as 97.22%, furthermore, the results of bacterial culture revealed that, many species of bacteria were identified with variety of percentages, these include: *Escherichia coli* (23.49%) followed by *Citrobacter spp* (20.95%), *Staphylococcus epidermidis*. (12.70 %), *Klebsiella spp.* (9.52 %), *Staphylococcus aureus* (8.89%), *P. aeruginosa*. (5.71%), *Proteus spp.* (5.40%), *Shigella spp.* (3.17%), *Streptococcus pyogens* (3.17%), *Salmonella spp.* (2.86%), *Streptococcus pneumonia* (2.54%), *Enterobacter spp.* (0.63%) and *Enterococcus spp.* (0.63%) as illustrated in Fig. 1. Significant differences (P<0.05) were observed among prevalence rates of different bacteria isolates.

The impact of month variation (season), currency denomination and currency papers sources on distribution of bacterial contamination on the currency papers were depicted in Table 1.

As shown, the highest contamination rate was recorded in month of February (24.44%); whereas, the lower in month of May (10.16%). The higher contamination rate was recorded in currency papers of 100-denomination; whereas, the lower rate in currency papers of 250-denomination. The highest contamination rate was recorded in health care workers' category working at Dhamar General Hospital (16.2%); whereas, the lower rate (12.70%) in workers working at Groceries. Statistically, significant differences (P<0.05) were observed between contamination rate and month variation; while, none with denomination and source of papers variables.

The antibiotics analysis of sensitivity and resistance patterns of the isolated bacteria showed increasing resistance of isolates to the methicillin and ceftazidime antibiotics; whereas, susceptibility to other antibiotic drugs with particular to Piperacillin / Tazobactam as depicted in Table 2.



**Table 1. The impact of month variation, currency denomination and currency`s source on distribution of bacterial contamination on Yemeni currency (n=315)**

Variable	Categories	No. of samples contaminated	Prevalence %	P value
Months	Jan	70	22.22	0.03
	Feb	77	24.44	
	Mar	70	22.22	
	Apr	66	20.95	
	May	32	10.16	
Currency denominations	1000 RY	78	24.76	0.452
	500 RY	75	23.81	
	250 RY	71	22.54	
	100 RY	91	28.89	
Source of currency paper	Restaurants	42	13.33	0.066
	Transports	46	14.60	
	Banks	46	14.60	
	Hospitals	51	16.19	
	Butchers` shops	46	14.60	
	Barber shops	44	13.97	
	Groceries	40	12.70	

**Table 2. Antimicrobial susceptibility pattern of bacterial isolates contaminated currency Papers**

Isolates	N	CXM			PTZ			MET			AX			AS			CAZ			P10			DOX			AV		
		S	M	R	S	S	M	R	S	M	R	S	M	R	S	M	R	S	M	R	S	M	R	S	M	R		
<i>S. epidermidis</i>	5	4	0	1	5	0	1	4	2	2	1	3	1	1	0	1	4	3	0	2	1	1	3	4	1	0		
<i>Citrobacter spp.</i>	4	0	3	1	4	0	0	4	1	3	0	1	3	0	0	1	3	0	1	3	2	2	0	3	1	0		
<i>E. coli</i>	3	1	2	0	3	0	0	3	2	1	0	3	0	0	0	0	3	2	1	0	1	2	0	3	0	0		
<i>Klebsiella spp.</i>	2	2	0	0	2	0	0	2	1	1	0	1	1	0	0	0	1	1	0	2	0	1	1	0	2	0		
<i>S. aureus</i>	4	3	1	0	4	0	0	4	3	0	1	4	0	0	2	0	2	3	1	0	1	2	1	2	2	0		
<i>Pseudomonas spp.</i>	3	2	0	1	3	1	0	2	0	2	1	2	0	1	1	1	1	1	1	1	2	0	1	2	1	0		
<i>Proteus spp.</i>	2	0	1	1	2	0	0	2	2	0	0	1	0	1	0	0	2	1	0	1	0	2	0	0	1	1		
<i>Shigella spp.</i>	2	1	1	0	2	0	0	2	2	0	0	2	0	0	0	0	2	2	0	0	2	0	0	2	0	0		
<i>Salmonella spp.</i>	4	2	2	0	4	0	0	4	3	1	0	4	0	0	0	0	4	2	2	0	3	1	0	2	0	2		
<i>S. pyogens</i>	2	2	0	0	2	0	0	2	0	2	0	1	1	0	0	1	1	1	0	1	2	0	0	1	0	1		
<i>S. pneumonia</i>	2	1	0	1	2	0	0	2	0	1	1	2	0	0	0	1	1	1	1	0	0	2	0	1	0	1		
<i>Enterobacter spp.</i>	2	2	0	0	2	0	0	2	1	1	0	1	1	0	0	0	2	1	0	1	1	0	1	1	1	0		

N= Number of Isolates, S=sensitive, M=Moderate, R= resistant, CXM= Cefuroxime, PTZ= Piperacillin / Tazobactam, MET= Methicillin, AX= Amoxicillin, AS= Ampicillin, CAZ= Ceftazidime, P10= Penicillin G, DOX= Doxycycline, VA= Vancomycine

## DISCUSSION

Currency papers are widely exchanged for goods and services in countries worldwide. Currency Papers are exchanged by persons with different hygiene habits, and are often stored under improper hygienic conditions. Although credit cards have replaced cash exchange in some cases, currency papers are still commonly used all over the world for the purchase of services and materials (Firoozeh et al., 2017).

Microorganisms that are present in air, water, etc., are easily spreading from one person to another. The most common mechanism of the spread of pathogens is by fomites including currency papers (Barolia et al., 2011; Elsharief and Haider, 2018). The main aim of this study was to investigate bacterial species contaminated Yemeni currency papers and associated factors in circulation at Dhamar city, Yemen.

The results of present study revealed that the bacterial contamination rate of Yemen currency papers was 97.52%. These results are in agreement with findings of Gabriel et al. (2013)) and Ejaz et al. (2018), who reported the contamination rate as 97%, and lower than contamination rates previously reported by Feglo and Nkansah (2010) in Ghana (98.6%); Moosavy et al. (2013) in Iran (100%); Hanash et al. (2016) in Yemen (100%); Allan et al. (2018) in Uganda (100%); Elsharief and Haider (2018) in Libya (100%); Sunil et al. (2020) in India (100%); El-dars and Hassan (2020) in Egypt (100%); and higher than rates recorded by Saadabi et al. (2017) in Saudi Arabia (96.2%); Barua et al. (2019) in Bangladesh (95%). The differences between the contamination rates of current study and above studies could be attributed to hygienic practices and handling of currency, economic and social habits of people in different countries.

Bacteria species isolated from the Yemeni currency paper were *S. epidermidis*, *Citrobacter spp.*, *E. coli*, *Klebsiella pneumonia*, *S. aureus*, *P. aeruginosa*, *Proteus spp.*, *Shigella spp*, *Salmonella spp.*, *S. pyogenes*, *S. pneumonia*, *Enterobacter spp.*, *Enterococcus spp.* with varied percentages. These results are partially or in complete accordance with findings of other researchers (Asikong et al., 2007; Oyer and Emikpe, 2007; Tagoe et al., 2009; Hiko et al., 2016; Saadabi et al., 2017; Dadgostar et al., 2017; Elsharief and Haider, 2018). Contrary or consistent

among the results of this study and findings of above workers may due to the environmental factors and size of sample. Furthermore, Sunil et al. (2020) suggested that, several behavioral practices in study site may contribute to currency contamination: keeping money underbody surfaces, improper washing of hands after using the toilet, wetting fingers with saliva when counting currency, coughing and sneezing on hands and handling currency, and placement or storage of money on dirty surfaces during transactions.

*E. coli* was found slightly predominant species compared to other species isolated; these results are in agreement with findings of Sunil et al. (2020) who assessed the microbial contamination of Indian currency papers in circulation and reported similar results. The predominant of *E. coli* species may due to the nature of this species and poor personal hygiene practices of currency handlers.

The impact of months (season), currency denominations and source of currency papers on distribution of bacterial contamination on currency papers also was investigated. The results displayed that, the higher contamination rate was recorded in month of February; whereas the lower in month of May. The higher contamination rate in February may be due that microclimate favor for survival and multiplication microorganisms in this month. All currency denominations papers investigated revealed that bacterial growth on lower denominations papers (100 YR) was more compared to higher denominations papers. These results are on line with previous studies conducted by many workers (Basavarajappa et al., 2005; Igumbor et al., 2007; Bhat et al., 2010; Anning et al., 2019; Yar, 2020). The reason behind that could be attributed to the lower denomination paper pass through more hands of people in diverse economic and social activities than the higher denomination papers which are often saved in banks, more respected and less frequently handled.

The currency papers obtained from hospitals and restaurants showed more bacterial contamination rate compared to groceries. These results are in agreement with findings of Ahmed et al. (2017). The relationship between contamination rate and source of currency papers may be attributed to variety of hygienic practices and handling of currency in different areas. Furthermore, hospitals are main sources for

nosocomial pathogens (Ejaz et al., 2018; Sunil et al., 2020).

Nowadays, antimicrobial resistance has become a burning issue throughout the world. Indiscriminate use of antibiotics has leads to treatment failure and augments health cost (Sharma and Dhanashree, 2011). Currency papers are usually contaminated with pathogenic microorganisms in circulation, of which most of them are resistant to commonly used antibiotics reported elsewhere world (Firoozeh et al., 2017). Transmission of these antibiotic resistance microorganisms from one individual to another through currency papers may cause serious public health hazards. In the current study, bacteria isolated from Yemeni currency paper were subjected to antimicrobial susceptibility test with nine commonly used antibiotics in markets; the results revealing that most of the antibiotic tested, namely, MET, CAZ and P<sub>10</sub> were non-effective against majority of bacterial isolates compared to Piperacillin / Tazobactam antibiotics tested. These results are partially in agreement with findings of Ali et al. (2015). The developed resistance of some isolates to tested antibiotics in our study may be attributed overuse and misuse of these medications, as well as a lack of new drug development by the pharmaceutical industry due to reduced economic incentives and challenging regulatory requirements as suggested by Gould and Bal (2013).

## CONCLUSION

It could be concluded from this study that, The Yemeni currency papers circulating among community people are contaminated with highly pathogenic and most of them resistant to common antibiotics used in markets. The pathogenic organisms represent risks and public health hazards to the community and individuals.

## RECOMMENDATIONS

This study could be recommended that, the decontamination of currency papers by ultraviolet light or formalin vapors at the banks and markets could help to reduce the transmission of the pathogen organism to human. It is also suggested that people should keep strict adherence to hygienic practices before handling food and water after contact with currency papers.

Assessment of bacterial resistance to common antibiotics should be performed regularly.

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## AUTHORS CONTRIBUTIONS

IRMS AlShaibani and HM Hatem, proposed, wrote protocol and final version of study. Authors, Akram AlHaj and Hisham AlMahdi, analyzed, interpretation of data. Authors, E A AlObbasi, AA, AlAmeen, EH AlSoffy, SH, AlSheni, BA Nahilah, A Al AlSanabany, carried out the collection, processing of specimen and antimicrobial susceptibility tests.

## CONFLICTS OF INTEREST

The Authors have not declared any conflict of interests.

## DATA AVAILABILITY

The data are available within text of the article.

## ETHICS APPROVAL

Not applicable.

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## التلوث البكتيري لأوراق العملة اليمنية وأنماط مقاومتها للمضادات الحيوية

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### الملخص

أجريت هذه الدراسة العرضية القطاع خلال الفترة 2021-2020م على أوراق العملة اليمنية، لمعرفة معدل انتشار التلوث البكتيري وعوامل الخطورة المرتبطة بها. كما تم اجراء اختبار أنماط الحساسية المضادة الحيوية للميكروبات الشائعة الملوثة لأوراق العملة اليمنية. تم جمع 324 عينة ورقية من العملة اليمنية من الفئات المختلفة بشكل عشوائي من أماكن مختلفة من مدينة ذمار. واجريت لكل عينة ورقية الزراعة الميكروبيولوجية والاختبارات البيوكيميائية. أظهرت النتائج أنه من إجمالي 324 عينة تم فحصها وجد أن 315 (97.22%) كانت موجبة وملوثة بنوع او اكثر من أنواع البكتيريا. كشفت النتائج المزعية ان تم التعرف على 14 أنواع من البكتيريا وهي: الإشريكية القولونية *E. coli* وسجلت بأعلى نسبة (23.81%)، تليها *Citrobacter spp* (18.73%)، *S. aureus* (8.57%)، *Klebsiella* (9.52%)، *epidermidis* (14.6%)، *Streptococcus* (5.4%)، *Shigella spp* (3.17%)، *Streptococcus pyogenes* (3.17%)، *Streptococcus*، *Salmonella spp* (2.86%)، *Enterobacter spp* (0.95%)، *Enterococcus spp* (0.63%)، *Pseudomonas spp* (6.03%)، *Proteus spp* (2.54%)، *pneumonia* (2.54%)، *Enterobacter spp* خيرا (0.63%). لوحظت فروق معنوية ذات دلالة احصائية ( $P < 0.05$ ) بين معدلات انتشار الأنواع البكتيرية المعزولة. لم يلاحظ اي ارتباط معنوي ( $P < 0.05$ ) بين تلوث أوراق العملة اليمنية والعوامل الديموغرافية. أظهر تحليل المضادات الحيوية لأنماط الحساسية والمقاومة لأنواع البكتيريا المعزولة في هذه الدراسة ان هناك مقاومة متزايدة Methicillin and Ceftazidime. بينما أظهرت كل من Piperacillin Tazobactam حساسية تجاه جميع البكتيريا بشكل عام. خلصت هذه الدراسة ان هناك عدة أنواع من البكتيريا تلوث العملة الورقية اليمنية في منطقة الدراسة. يوصى بتعقيم العملة اليمنية في البنوك بالمعقمات الخاصة لتقليل فرص اصابة الانسان بالأنواع المعزولة من البكتيريا وغيرها.

**الكلمات المفتاحية:** مقاومة المضادات الحيوية، التلوث البكتيري، العملة الورقية اليمنية

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## Original Article

# Effect of Ginger Extract and Polyphosphate on Microbiological Properties of Chicken Meat

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### KEYWORDS

Chicken Meat,  
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Polyphosphate

### ABSTRACT

The present study was aimed to evaluate the effect of Trisodium phosphate (TSP), fresh ginger rhizome extract (GE) and their mix on some microbiological properties of chicken meat. The chicken carcasses samples were collected after evisceration processes and before coming in to the immersion chiller, from the production line of private automatic poultry slaughter-house in Dhamar city, Yemen. The chicken `s carcasses were divided into four treatment groups and control: The G-I was acts as control (3 carcasses), G-II (6 carcasses), G-III (6 carcasses) and G-IV (3 carcasses) were dipped in 3 and 5% ginger extracts, 6 and 8% TSP solutions and mix of TSP (6%) and ginger extract (3%) respectively. Measurements were taken before and post treatment at 0, 48 and 72 hrs. at  $4\pm 1^{\circ}\text{C}$ . The results showed a significant reducing ( $P < 0.05$ ) in populations of total bacteria counts and *Staphylococcus* by 0.85 and 0.79 log cfu/ml in treated group with 8% TSP; while, in treated groups with 6%, 8% TSP and with the mix of (3% GE + 6 % TSP) caused a significant reduction in *Salmonella* counts by 0.82, 1.05 and 0.89 log cfu/ml respectively. Changes in microbial loads during cold storage indicated that chicken meat group treated with 8% TSP resulted in a significant reduction in total bacterial counts by 3.45 log cfu/ml compared to control group 4.36 log cfu/ml after 48 hrs. of storage at  $4\pm 1^{\circ}\text{C}$ ; while, *Salmonella* count was significantly reduced by 2.46 log cfu/ml as compared to control 3.78 log cfu/ml after 72 hrs. of storage at  $4\pm 1^{\circ}\text{C}$ . In conclusion, Trisodium phosphate, ginger, and Trisodium phosphate and ginger in combination at different concentration exhibited antibacterial activities in reduction of bacterial counts and load on chicken meat. Trisodium phosphate compound showed more efficacy compared to ginger extracts. The treatments of chicken meat with TSP, GE and their mix increased the shelf life of the meat. Further studies are needed to study the effect of other plant extract on microbiological properties of chicken meat.

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## INTRODUCTION

The consumption of poultry meat is increasing around the world, due to it is a low in fat, rich in protein and low price (OECD/FAO, 2021; Wang et al., 2023; Henchion et al., 2014; Bordoni and Danesi, 2017). In addition, several key factors contribute to chicken's dominance in the global meat market, including

affordability, nutritional value, palatability, and ease of preparation (Petracci, 2022; Shaltout et al., 2023). In spite of, the relative safety and nutritional value of fresh chicken meat, its physicochemical properties make it prone to microbial spoilage. As it is exposed for microbial contamination from various sources (Al-

Maaqar et al., 2023). The presence of foodborne pathogens in poultry represents a significant threat to the poultry meat industry due to huge economics caused by these organisms. These pathogenic bacteria, naturally present in the gut of chickens, can contaminate the meat during processing the carcasses in plants, posing a serious health risk to consumers (Maharjan et al., 2019; Tahir et al., 2024). The common pathogenic bacteria associated with poultry are *Salmonella*, *Campylobacter*, *Staphylococcus aureus*, *E. coli*, and *Listeria*, (Bhaisare et al., 2014). Some treatments are applying for poultry carcasses to improve the microbiological quality parameters such as the treatment with sodium chloride, sodium lactate, Trisodium phosphate and plant extracts. Several plants extracts are used against the bacterial activities on poultry meat such as rosemary, garlic, pineapple and ginger extracts, (Khaled, 2016; Hmiadei et al., 2010).

Ginger contains some volatile compounds such as  $\alpha$ -pinene, borneol, camphene, and linalool, which are responsible for antimicrobial activities, (Nychas and Skandamis, 2003; Sa-Nguanpuag et al., 2011). The major pungent components of ginger are gingerone and gingerol, which have strong inhibitory activity against pathogenic bacteria (Park et al., 2008). The ginger essential oil contains amounts of phenolic compounds i.e. eugenol, shogaols, zingerone, gingerdiols and gingerols, which might be responsible for antimicrobial potency (Singh et al., 2008).

In previous studies, the dipping of slices spent hen breasts in 3 and 5% ginger solution with added 2% of salt and stored for 24 hrs at 4°C showed a significant reduction in population of total bacterial count by 4.83 and 4.16 log cfu/g, respectively, compared to control 6.20 log cfu/g (Zangana and Aljami, 2010). The Treating camel meat chunks with 30% ginger extract by spraying reduced the total bacterial count and *Staphylococcus aureus* count to  $3.1 \times 10^5$  and  $2.5 \times 10^2$  cfu/g, respectively, compared to the control counts of  $7.8 \times 10^5$  and  $8.6 \times 10^2$  cfu /g, while after 3 days of storage at  $4 \pm 1^\circ\text{C}$  the total bacterial count and *Staphylococcus aureus* counts were reduced to  $7.9 \times 10^5$  and  $5.1 \times 10^2$  cfu/g compared to the counts in control  $5.2 \times 10^6$  and  $2.4 \times 10^3$  cfu/g respectively (Abdeldaiem and Ali, 2014).

Trisodium Phosphate (TSP) is generally known as safe by the US (FDA) and has been approved by USDA-FSIS at levels of 8-12% as an antimicrobial agent on raw chilled poultry carcasses that have been passed for wholesomeness (Capita et al., 2002).

Carcasses are either spray or dip in TSP solution for up to 15 sec at  $13 - 17^\circ\text{C}$  (Federal Register, 1994).

Treatment of poultry carcasses with TSP was effective in reducing populations of food-borne pathogens including *Salmonella*, *Campylobacter*, *Escherichia coli O157:H7*, *Listeria* and *Staphylococcus aureus* as well as spoilage bacteria including *Pseudomonas* and *Lactobacillus* (Ledesma et al., 1996; Capita et al., 2002). The dipping of chicken breast samples in 5%, 8% and 10% TSP solutions for 15 min at room temperature  $25^\circ\text{C}$  cause a reducing in the aerobic plate count and *Staphylococcus* counts to 7.69, 6.32, 5.69, 3.56, 3.32 and 2.07 log cfu/g compared to control 8.2 and 4.30 log cfu/g, respectively (Hemmat et al., 2016).

In light of the growing need for safe and healthy food and to limit the proliferation of microorganisms that cause meat spoilage, improving meat quality has become essential. This can be achieved by reducing or eliminating microorganisms, whether they cause spoilage or deterioration of chicken meat. Therefore, the aim of this study was to investigate the effect of Trisodium phosphate (TSP) and fresh ginger rhizome extract (*Zingiber officinale*) extract at different concentration on total counts and load of *Staphylococcus* and *Salmonella* of chicken meat under refrigerated storage.

## MATERIALS AND METHODS

### Samples Collection

A total of eighteen fresh whole chicken carcasses (30–35 days old and weight of 1100 to 1200g) were randomly, Yemen. Chicken were slaughtered by butcher (bled for 2.22 min), scalded for 1.36 min at  $58^\circ\text{C}$  and mechanically de-feathered for 53 sec. All selected from the production line of private automatic poultry slaughter-house in Dhamar city. Carcasses were collected after the evisceration processes and before coming in to the immersion chiller.

### Preparation of chemical solutions and plant extracts Trisodium phosphate (TSP)

Trisodium phosphate 98% (made in China) was purchased from a local market in Sana'a, Yemen. TSP was used to prepare 6 % and 8% solutions in sterile water.

### Ginger extract

Ginger extract was prepared according to the (Indu, et. al. 2006). Fresh ginger rhizomes (*Zingiber*

officinal) were purchased from a local market in Dhamar city, Yemen. The fresh ginger rhizomes were cleaned, peeled, sliced and washed in sterile water. In order to obtain aqueous extract of the ginger rhizomes, 100g of washed ginger rhizome was crushed using mortar, then blender was used to obtain ginger extract. After then, the extract was filtered through filter paper and sterilized by using a syringe filter (made in Taiwan). This extract was considered as the 100% concentration of the extract. The concentrations of 3% and 5% were made by diluting the concentrated extract with appropriate volumes of sterile water. The extracts were prepared fresh before each trail.

### Experimental design and measurements

The chicken's carcasses were divided into four treatment groups and control as following: The group-I was acts as control (3 carcasses), group -II (6 carcasses), group -III (6 carcasses) and group -IV (3 carcasses) were received treatment through dipped in 6 and 8% TSP solutions, 3 and 5% ginger extracts, and mix of TSP (6%) and ginger extract (3%) respectively for 15 min. at  $18\pm 2^{\circ}\text{C}$ .

After treatments, the carcasses were removed from the solutions, rinsed with sterile water to remove residual solutions, and drained for 5 -10 min. The carcasses were packed separately in sterile polyethylene bags and stored at  $4\pm 1^{\circ}\text{C}$  for 48 and 72 hrs. Measurements were taken before and post treatment at 0, 48 and 72 hrs. at  $4\pm 1^{\circ}\text{C}$ . The results were expressed as log cfu/ml of rinse.

### Microbiological analysis

The microbial counts of the carcasses were assessed according to the (Roberts and Greenwood, 2003; Simmons et al., 2003). The carcass rinse method was used as technique for microbiological analysis. The technique in brief, carcasses were shaken for 1-2 min in 500 ml of sterile water in sterilized polyethylene bags (41×41 cm). Twenty-five ml of the rinsing solution was transferred to 225 ml of sterile buffered peptone water and shaken to homogenate carefully. A series of decimal dilutions were made with buffered peptone water from this solution, for the microbiological analysis.

### Total bacteria counts

The total bacterial counts were determination by poured method and plate count agar (Himedia Laboratories Pvt. Ltd, India). One ml of the series of decimal dilutions was poured in petri dishes and molten media was added

then incubated at  $37^{\circ}\text{C}$  for  $24\pm 2$  hrs. under aerobic conditions.

### *Staphylococcus* counts

*Staphylococcus* counts were determined as described above for total bacterial counts except that media culture were Baird-Parker Agar (Himedia Labs. Pvt. Ltd, India).

### *Salmonella* spp. counts

*Salmonella* count were determination by poured plate and decimal dilution using Selenite Cysteine Broth with sodium chloride solution (0.9%). 1 ml of decimal dilutions was poured in petri dishes and *Salmonella* and *Shigella* agar (SSA) was added (Himedia Labs. Pvt. Ltd, India). The petri dishes were incubated at  $37^{\circ}\text{C}$  for  $24\pm 2$  hrs. Colonies with black or black center were counts.

### Estimate of microbial load reduction

Microbial counts were transformed to  $\log_{10}$  cfu/ml values. The reduction of microbiological load was calculated according to following formula:

$$\text{Reduction \% (log}_{10}\text{ cfu/ml)} = W_1 - W_2$$

Where:  $W_1$ : microbial counts before treatment,  $W_2$ : microbial counts after treatment

### Statistical Analysis

Microbial counts were transformed to  $\log_{10}$  cfu/ml values. The data were subjected to analysis of variance with a confidence level of ( $P < 0.05$ ) and expressed as the mean  $\pm$  and standard deviation. The comparisons among mean values were carried out by using Duncan's comparison test. The SPSS Statistics Version 22.0 software was used for data analysis.

## RESULTS AND DISCUSSION

### Effect of TSP, GE and their mix on microbiological properties

#### Reduction of the microbial load in chicken meat

Table 1. Shows the treatments results of raw whole chicken meat with TSP, GE, their mix and reduction of total bacterial counts of *Staphylococcus* and *Salmonella*.

The treatment of chicken meat with 8% TSP solution exhibited a significant reduction ( $P \leq 0.05$ ) in total bacteria and *Staphylococcus* counts compared to other treated groups. The total bacterial counts (TBC) and *Staphylococcus* counts were reduced to 0.85 and 0.79 log cfu/ml respectively. The treatment with 6% TSP, 3 and

5% GE and their mix solution caused a reducing in the total bacterial counts and *Staphylococcus* counts. The TBC and *Staphylococcus* counts were reduced to 0.72, 0.17, 0.25, 0.78, 0.67, 0.18, 0.29 and 0.72 log cfu/ml in (6%) TSP, (3 and 5%) GE and their mix respectively.

Treatment of raw chicken carcasses at concentrations of 6 and 8% TSP and mix of GE +TSP showed a significant reduction ( $P \leq 0.05$ ) on *Salmonella* counts compared to GE treated groups. These counts were reduced to 0.82, 1.05 and 0.89 log cfu/ml in (6 and 8%) TSP and mix of (GE +TSP), respectively, while they were reduced to 0.1 and 0.21 log cfu/ml in in group treated with 3 and 5% GE extract respectively.

The results of this study indicated that the treated groups with 8%TSP showed the highest reductions on *Salmonella* counts, TBC and *Staphylococcus* counts respectively. The effect of TSP may be due to its high pH (about 11 -12) and ionic strength, which can influence the reduction in bacterial counts. The current results are in agreement either in complete or partially with findings of other workers in different geographical regions in the world for example: Lillard (1994; Lillard (1994) in USA; Sampathkumar et al., (2003) in Canada; Capita et al., (2002) in France; Bin Jasass (2008); Sudarshan et al., (2010; Capita et al., (2000); Abdeldaiem and Ali (2014); Hemmat et al., (2016); Singh, (2016); Selvan and Mendiratta (2019); Uysal et al., (2020);) who studied the effect of TSP, Ginger and their mixture in reduction of microbial load/counts of on *Salmonella* and *Staphylococcus* counts chicken meats in different concentrations and temperature conditions and reported TSP, Ginger and their mixture reduced significantly the total bacterial counts and *Staphylococcus* and *Salmonella* counts. However, the findings of present result disagreeing with findings of Hutton et al., (1991); Zingano and Aljami (2010). The contrary or consistent between current results and findings of above studies could be attributed to the period of dipping in treatments solutions, addition of salt to treatments solutions, pH, and processing techniques used.

### Effects of treatments in microbial load of chicken meat during cold storage

#### Total bacterial count of chicken meat during cold storage

Table 2. Shows the results treatments of raw whole chicken meat with TSP, GE and their mix on total bacterial count during cold storage. The treatments at concentration of 8% TSP solution exhibited a significant reduction ( $P \leq 0.05$ ) on total bacterial counts compared

to control group. These counts were reduced to 3.35 and 3.45 log cfu/ml with 8%TSP solution; while the count in control was 4.32 and 4.36 log cfu/ml after 0 and 48 hrs. of storage at  $4 \pm 1^\circ\text{C}$ , respectively. The treatments at concentrations of 6% TSP and the mix of (GE +TSP) showed a significant reduction ( $P \leq 0.05$ ) in TBC in treated group compared to control group. These counts were reduced to 3.54 and 3.52 log cfu/ml TSP and mix of (GE +TSP) respectively, while the count in control was 4.32 log cfu/ml after 0 hrs. of storage at  $4 \pm 1^\circ\text{C}$ .

Treatment of raw chicken carcasses with 6 and 8% TSP, 3 and 5% GE and their mix solutions resulted in a reduction in the total bacterial counts of treated groups compared to control. These counts were reduced to (3.71 and 3.45), (4.41 and 4.33) and (3.68) log cfu/ml, in treated group respectively, while the count in control 4.48 log cfu/ml after 72 hrs of storage at  $4 \pm 1^\circ\text{C}$ . However, TBC were reduced to (3.69), (4.30 and 4.26) and (3.65) log cfu/ml in groups treated with (6%) TSP, (3 and 5%) GE and their mix, respectively, while in control was 4.36 log cfu/ml after 48 hrs of storage at  $4 \pm 1^\circ\text{C}$ . in addition, the counts were reduced to 4.16 and 4.10 log cfu/ml in groups treated with (3 and 5%) GE solution respectively, after 0 hrs of storage. The higher reduction observed in the group treated with 8% TSP, this may due to the higher concentration used, period of storage and processing technique used.

Similar studied have been carried out on the treatments effect of TSP and GE on total microbial load of chicken meat during cold storage by many workers (Kim et al., (1994); Okolocha and Ellerbroek (2005); Capita et al (2000) ; Del Río et al., (2007); Abdeldaiem and Ali (2014); Khaled (2016); Abdel-Naeem et al., (2022) and researched to similar results. However, the results findings reported by Babatunde and Adewumi (2015) were in discrepancy with above mentioned findings. The reasons behind varying effects of TSP and GE on TBC could be attributed to several factors including contact time, TSP and ginger concentrations, application method, temperature, and exposure period of storage.

#### *Staphylococcus* count of chicken meat during cold storage

The results in Table 3. Shows the effects of treatments by TSP, GE and their mix on *Staphylococcus* bacteria count of raw whole chicken meat during cold storage. The treatments with both (6 and 8%) TSP, (3 and 5%) GE and their mix solution showed a reducing in *Staphylococcus* counts but not significant ( $P < 0.05$ ) compared to control group. These counts were reduced

from 3.75, 4.24 and 3.89 log cfu/ml in the control to (3.12 and 2.86), (3.55 and 3.48) and (3.05), (3.49 and 3.12), (4.03 and 3.94), (3.48), (3.58 and 3.20), (3.77 and 3.69) and (3.52) log cfu/ml in (6 and 8%) TSP, (3 and 5%) GE and their mix after 0, 48 and 72 hrs of storage at 4±1°C respectively.

These results indicated that the samples treated with (8%) TSP showed a highest reduction in the numbers of *Staphylococcus* after 48 hrs of storage at 4±1°C. Similarly, Ledesma et al., (1996) studied the effect of TSP, GE and their mix on *Staphylococcus* bacteria count of chicken meat during storage on *Staphylococcus* counts and reported that the dipping of chicken wings in 10% TSP for 15 sec. at 10°C caused a significant reduction on *Staphylococcus aureus* count by 80.33% and 54.45% respectively after overnight storage at 4 and 10°C. Abdeldaiem and Ali, (2014) also reported that the treating of camel meat chunks with 30% ginger extract by spray caused a reducing in the *Staphylococcus aureus* count to 2.5 x 10<sup>2</sup> and 5.1x10<sup>2</sup> cfu/g, compared to control 5.1 x 10<sup>2</sup> and 2.4 x 10<sup>3</sup> cfu/g after 0 and 3 days of storage at 4±1°C, respectively.

**Salmonella spp. of chicken meat during cold storage.**

Table 4. Shows the results treatments of raw whole chicken meat by TSP, GE and their mix for reduction *Salmonella* count during cold storage. The treatment at concentration of 8% TSP solution showed a significant decrease (P ≤ 0.05) in population of *Salmonella* compared to control group. These counts were reduced to 2.45 and 2.46 log cfu/ml; while, the count in control was 3.55 and 3.78 log cfu/ml after 0 and 72 hrs respectively of storage at 4±1°C. There were no significant differences (P<0.05) in the population of *Salmonella* in chicken meat treated group with 8% TSP compared to the control after 48 hrs. of storage at

4±1°C. This count was reduced from 3.8 log cfu/ml in the control to 2.69 log cfu/ml in 8% TSP treated group. The treatments at the concentrations of 6%TSP, 3 and 5% ginger and their mix exhibited reduction in *Salmonella* counts. These counts were reduced from 3.55, 3.8 and 3.78 log cfu/ml in control group while; 2.75, (3.48 and 3.4), (2.68), (3.09), (3.56 and 3.51), (3.01), (3.28), (3.64 and 3.54) and (3.17) log cfu/ml in groups treated with 6% TSP, 3 and 5%) ginger and their mix respectively after 0, 48 and 72 hrs of storage at 4±1°C. The higher reduction of *Salmonella* in chicken meat treated group with 8% TSP may be attributable to the increased concentration of TSP used and the storage period.

In this context Kim et al., (1994) reported that the dipping of chicken carcasses inoculated with high levels of *salmonellae* in 10 % TSP solution at either 10 or 5°C for 15 sec and stored for 6 days at 4°C caused a significant reduction on *Salmonella* count by 1.6 and 1.8 logs on day 1 and day 6 of cold storage respectively. They conclude that the difference in log reductions between the first day and the six days of storage may be due to the supports the residual effect of TSP on bacterial reduction during six-day storage at 4°C. Fabrizio et al. (2002) reported that the reductions of *Salmonella typhimurium* were 0.9 log<sub>10</sub> and 2.17 log<sub>10</sub> cfu/ml at both 0 and 7 days of storage at 4°C respectively, when half carcasses were spray washed with 10% TSP for 45 min (85 psi, 25°C, 15 sec). Ledesma et al., (1996) reported that the dipping of chicken wings in 10% TSP for 15 sec at 10°C showed a significant reduction on *Salmonella typhimurium* count by 93.45% and 62.42% after overnight storage at 4 and 10°C, respectively.

**Table 1. Effect of Trisodium phosphate, Ginger extract and their mix on microbial load reduction on chicken meat**

Reduction(log cfu/ml)	TSP		Ginger		GE+ TSP
	6%	8%	3%	5%	3 %+6%
<b>Total bacterial count</b>	0.72 ± 0.41abc	0.85 ± 0.25c	0.17 ± 0.25 a	0.25 ± 0.34ab	0.78 ±0.17bc
<b>Staphylococcus</b>	0.67 ± 0.08ab	0.79 ± 0.55b	0.18 ± 0.08 a	0.29 ± 0.28ab	0.72 ± 0.09ab
<b>Salmonella</b>	0.82 ±0.40b	1.05 ± 0.03b	0.10 ± 0.06 a	0.21 ± 0.01 a	0.89 ± 0.27b

\* Different letters mean significant differences within a column (P ≤ 0.05)

**Table 2. Effect of Trisodium phosphate, Ginger extract and their mix on total bacterial counts of chicken meat during storage**

Treatments	Concentrations	Storage time (hrs.)		
		0	48	72
Control	-	4.32 ± 0.54 c	4.36 ± 0.19 b	4.48 ± 0.58 a
TSP	6%	3.54 ± 0.58 ab	3.69 ± 0.74 ab	3.71 ± 0.96 a
	8%	3.35 ± 0.21 a	3.45 ± 0.22 a	3.45 ± 0.12 a
Ginger	3%	4.16 ± 0.19 bc	4.30 ± 0.1 b	4.41 ± 0.23 a
	5%	4.10 ± 0.33 abc	4.26 ± 0.48 b	4.33 ± 0.48 a
Mix	3% G + 6% TSP	3.52 ± 0.43 ab	3.65 ± 0.37 ab	3.68 ± 0.52 a

\* Different letters mean significant differences within a column ( $P \leq 0.05$ ).

**Table 3. Effect of Trisodium phosphate, Ginger and their mix on *Staphylococcus* bacteria counts of chicken meat during storage**

Treatments	Concentrations	Storage time (hrs.)		
		0	48	72
Control	-	3.75 ± 0.22 a	4.24 ± 0.72 a	3.89 ± 0.95 a
TSP	6%	3.12 ± 0.19 a	3.49 ± 0.99 a	3.58 ± 1.23 a
	8%	2.86 ± 0.50 a	3.12 ± 0.55 a	3.20 ± 0.92 a
Ginger	3%	3.55 ± 0.57 a	4.03 ± 0.15 a	3.77 ± 0.4 a
	5%	3.48 ± 1.09 a	3.94 ± 0.57 a	3.69 ± 0.52 a
Mix	3% G + 6% TSP	3.05 ± 0.04 a	3.48 ± 0.07 a	3.52 ± 0.04 a

\* Different letters mean significant differences within a column ( $P \leq 0.05$ ).

**Table 4. Effect of Trisodium phosphate, Ginger and their mix on *Salmonella* spp. counts in chicken meat during storage**

Treatments	Concentrations	Storage time (hrs.)		
		0	48	72
Control	0.0	3.55 ± 0.37 b	3.8 ± 0.89 a	3.78 ± 0.68 b
TSP	6%	2.75 ± 0.1 ab	3.09 ± 0.45 a	3.28 ± 0.36 ab
	8%	2.45 ± 0.32 a	2.69 ± 0.49 a	2.46 ± 0.7 a
Ginger	3%	3.48 ± 0.15 b	3.56 ± 0.15 a	3.64 ± 0.38 b
	5%	3.4 ± 1 b	3.51 ± 0.99 a	3.54 ± 0.58 ab
Mix	3% G + 6% TSP	2.68 ± 0.22 ab	3.01 ± 0.19 a	3.17 ± 0.75 ab

\* Different letters mean significant differences within a column ( $P \leq 0.05$ ).

## CONCLUSIONS AND RECOMMENDATIONS

Trisodium phosphate, ginger, and Trisodium phosphate and ginger in combination at different concentration exhibited antibacterial activities in reduction of bacterial counts of chicken meat. Trisodium phosphate compound showed more efficacy compared to ginger extracts. The treatments of chicken meat with TSP, GE and their mix increased the shelf life of the meat.

Further studies are needed to study the effect of other plants extract on microbiological properties of chicken meat.

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#### AUTHORS CONTRIBUTIONS

FMA and AMAI, both authors contributed equally on protocol proposal, collection, processing the specimen, analyzed, interpretation of data and wrote final version of Manuscript. Both Authors have approved this version of the manuscript.

#### CONFLICTS OF INTEREST

The author(s) declare no conflicts of interest with respect to the authorship and/or publication of this article.

#### DATA AVAILABILITY

The data are available within text of the article.

#### ETHICS APPROVAL

This study was conducted after approval from Faculty of Agriculture, Tamar University, Yemen.

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## تأثير مستخلص الزنجبيل والبولي فوسفات على الخواص الميكروبيولوجية للحوم الدواجن

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### الملخص

هدفت الدراسة إلى تقييم تأثير المعاملات بثلاثي فوسفات الصوديوم (Trisodium Phosphate) ومستخلص جذور الزنجبيل الطازج (Fresh Ginger Rhizome Extract) ومزيجهما على بعض الخواص الميكروبيولوجية (Total bacterial count, *Staphylococcus* and *Salmonella* counts) للحوم الدجاج. تم جمع عينات ذبائح الدجاج من خط الانتاج بعد مرحلة نزع الأحشاء وقبل دخولها إلى حوض التبريد بالماء. قسمت ذبائح الدجاج إلى أربع مجموعات: شملت مجموعة السيطرة (الأولى) وثلاث مجموعات معالجة (الثانية، الثالث، والرابعة)، تضمنت الأولى 3 ذبائح، والثانية والثالثة والرابعة على 6 و 6 و 3 ذبائح على التوالي. تم معاملة ذبائح الدجاج (مجموعات المعالجة) بالغمر في محاليل تحتوي على 3% و 5% من مستخلص الزنجبيل (GE) و 6% و 8% من ثلاثي فوسفات الصوديوم (TSP) ومزيجهما (6% TSP + 3% GE) لمدة 15 دقيقة عند درجة حرارة 2±18 م. تم إجراء العد الميكروبي للذبائح الدجاج قبل وبعد المعاملات وأثناء التخزين بالتبريد عند 4±1 م بعد 48 و 72 ساعة. أظهرت النتائج حدوث انخفاض معنوي ( $P < 0.05$ ) في أعداد البكتيريا الكلية والمكورات العنقودية (*Staphylococcus* count, total bacterial count) بمقدار 0.85 و 0.79 (لو خلية/مل) في العينات المعاملة بـ 8% TSP، بينما المعاملة بـ 6% و 8% TSP ومزيج من (3% GE + 6% TSP) أدت إلى انخفاض معنوي في أعداد السالمونيلا (*Salmonella* count) بمقدار 0.82 و 1.05 و 0.89 (لو خلية/مل) على التوالي. كما أشارت نتائج دراسة التغير في الحمل الميكروبي في لحوم الدجاج خلال الخزن بالتبريد إلى أن المعاملة بـ 8% TSP أدت إلى انخفاض معنوي في أعداد البكتيريا الكلية بمقدار 3.45 (لو خلية/مل) مقارنة بعينة السيطرة التي كانت 4.36 (لو خلية/مل) بعد 48 ساعة من التخزين عند 4±1 م، بينما انخفض عدد السالمونيلا معنويًا بمقدار 2.46 (لو خلية/مل) مقارنة بعينة السيطرة التي كانت 3.78 (لو خلية/مل) بعد 72 ساعة من التخزين عند 4±1 م. خلصت هذه الدراسة إلى أن فوسفات ثلاثي الصوديوم والزنجبيل وفوسفات ثلاثي الصوديوم والزنجبيل معًا بتركيزات مختلفة، أظهرت فعالية في خفض أعداد السالمونيلا والعدد الكلي للبكتيريا وأعداد المكورات العنقودية، كما أدت إلى تحسين الجودة الميكروبيولوجية للحوم الدجاج خلال فترة الخزن بالتبريد، أظهرت فوسفات ثلاثي الصوديوم أكثر فعالية مقارنة بالمعاملات الأخرى التي استخدمت في هذه الدراسة. يوصى بأجراء المزيد من الدراسات، لدراسة تأثير المستخلصات النباتية الأخرى على الخصائص الميكروبيولوجية للحوم الدجاج.

**الكلمات المفتاحية:** لحوم الدواجن، مستخلص الزنجبيل، الخواص الميكروبيولوجية، البولي فوسفات.

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## Original Article

# أثر قبول انضمام اليمن لمنظمة التجارة العالمية على كفاءة التجارة الخارجية

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## الكلمات المفتاحية

## الملخص

اليمن، منظمة التجارة العالمية، التجارة الخارجية

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كان هدف انضمام اليمن لمنظمة التجارة العالمية هدفاً للحكومات اليمنية المتعاقبة وفي سبيل تحقيق ذلك الهدف دخلت في مفاوضات طويلة وشاقة وقد اخذت اليمن نحو ثلاث عشر سنة من تاريخ تقديم طلب الانضمام رسمياً وقد استمرت في العمل الشاق والجهد الوطني المتواصل لتحقيق ذلك الهدف، وفي ديسمبر 2013 تم قبول طلب اليمن لتصبح العضو رقم 160 في منظمة التجارة العالمية. هدفت هذه الدراسة الى استكشاف وضع التجارة الخارجية اليمنية من خلال دراسة المؤشرات الاقتصادية لوضع التجارة الخارجية ومعرفة أثر قبول انضمام اليمن للمنظمة من خلال التعرف على اهم مؤشرات كفاءة التجارة الخارجية ومع التركيز على دراسة تلك المؤشرات خلال فترتي الدراسة والتي قسمت الى ما قبل قبول انضمام اليمن لمنظمة التجارة العالمية كفترة أولى وما بعد قبول انضمام اليمن الى المنظمة كفترة ثانية. وقد اعتمدت الدراسة على المنهج التحليلي الوصفي والكمي إضافة الى استخدام أساليب بحثية تخدم البحث. واستندت الدراسة على البيانات الثانوية المنشورة وغيرها والمجمعة من التقارير والاحصائيات الصادرة من الجهات الحكومية. وقد توصلت الدراسة الى أن الفترة الثانية شهدت تناقص في متوسط الصادرات بينما تزايد متوسط الواردات لذلك ارتفع عجز الميزان التجاري، كما تبين ان متوسط معظم المتغيرات الاقتصادية ومؤشرات الدراسة في الفترة الثانية قد تناقصت باستثناء الواردات والنتاج المحلي، كما اتضح ان هناك ارتفاع في درجة التركيز للصادرات والواردات في فترتي الدراسة، وتبين ان اليمن لم تستفيد من توفير بعض الفترات الزمنية الانتقالية ولا من أي مميزات كانت ستقدم لليمن في اثناء الفترة الانتقالية والتي أعقبت تاريخ قبول اليمن من الدول الأقل نمواً. توصى الدراسة بضرورة المصالحة الوطنية وانهاء الحرب والعمل على إعادة النظر في السياسات المتبعة في مجال التجارة الخارجية لما يكون في مصلحة اليمن والعمل مع المجتمع الدولي لإزالة الآثار وتحسين الوضع الاقتصادي والتجاري، والعمل مع الجهات الدولية المختصة باعتبار الفترة التي تعرضت لها اليمن من قلاقل وحرب لا تؤثر على المميزات التي كانت اليمن موعودة بها.

## المقدمة Introduction

ما أدى الى اقتتال داخلي عرفت بحرب صيف 1994 ولم تولى الحكومة في ذلك الوقت أي اهتمام بعملية الانضمام للمنظمة العالمية الوليدة وهي منظمة التجارة العالمية وضاعت فرصة انضمام اليمن للمنظمة كدولة اقل نمواً وفقاً للمادة (2,11) وكان البديل الطبيعي هو الانضمام لاحقاً وفقاً للمادة (12) الأكثر مشقة، حيث يتم الانضمام وفقاً لشروط يتم الاتفاق عليها بين الدول الساعية للعضوية وجميع أعضاء المنظمة، ومن وجهة ثانية قامت الحكومة على تطبيق سياسة الإصلاح الاقتصادي في اليمن والذي ابتداء في مارس 1995 ونفذت تغييرات جذرية في مسارات السياسات الاقتصادية والتجارية منها بالدرجة الاساس بتجاه عولمة الاقتصاد اليمني، فإنها اتخذت أيضاً،

قد يكون انشاء منظمة التجارة العالمية من أكثر المواضيع التي أثارت اهتماماً عالمياً وتم تناولها نقداً وتحليلاً، سلباً وإيجاباً، فالبعض اعتبرها فرصة والبعض اعتبرها خطر وآخرين اعتبروها فرصة وخطر في آن واحد. حيث انها فرصة إذا أحسن التعامل معها، وخطر إذا لم يتم التعامل معها والإعداد لها بالشكل المناسب، في حين اعتبرها الكثيرون شراً لا بد منه وفي اول يناير 1995 أنشأت منظمة التجارة العالمية كأحد النتائج الرئيسية لجولة أوروغواي. وقد شاركت 123 دولة في انشاء منظمة التجارة العالمية (اتفاقية الجات 1994) بديلاً للجات 1947 (عديريه، وليد، 2006). وفي ابريل 1994 كانت اليمن في غاية التعقيد والانشغال بالشأن السياسي الداخلي المتفاهم وهو

لسنة 2014 بعد موافقة مجلسي الوزراء والنواب بشأن الموافقة على البروتوكول الموقع بتاريخ 4 ديسمبر 2013م بانضمام الجمهورية اليمنية الى منظمة التجارة العالمية. وخلصت برتوكول انضمام اليمن الى المنظمة وملحقاته فيما يسمى بحزمة وثائق الانضمام للمنظمة. وقد سعى اليمن عبر المفاوضات الطويلة والشاقة وتقدير الأعضاء لحقائق الأمور على الأرض في كل حالة للحصول على عدد من الفترات الانتقالية المناسبة في إطار المعاملة الخاصة والتفضيلية المتاحة للدول الأقل نمواً (حاميم، 2014). فلم يعد بإمكان أي دولة ان تعيش خارج إطار النظام التجاري الدولي المتعدد الأطراف والذي تمثله منظمة التجارة العالمية، وان بقيت دولة خارجة فأنها ستكون عرضة للتهميش والممارسات التجارية الغير عادلة (المرزوقي، 2005).

وبعد انضمام اليمن لمنظمة التجارة العالمية وفي الأيام الأولى شهدت العلاقة بين اليمن والصين تطور كبير، وتم عقد حزمة من الاتفاقيات للتعاون الاستثماري والمستقبلي بين البلدين في مختلف المجالات. وتعتبر الصين الشريك التجاري الأكبر لليمن فقد بلغ حجم التبادل التجاري في العام الأول لانضمام اليمن لمنظمة التجارة العالمية 2014 حوالي 723 مليار ريال بزيادة مقدارها حوالي 26% عما كانت عليه في عام 2013. وبدء من 21 مارس 2014 تعرضت اليمن لمرحلة غاية في التعقيد والانشغال بالشأن الداخلي والذي تفاقم الى تعقد الوضع الاقتصادي والسياسي نجم عن ذلك نشوب صراعات واقتتال (عصام، 2023).

#### الدراسات السابقة

توصل قائد (2006) الى ان قيمة الواردات الكلية الزراعية اليمنية تزيد بمعدل أكبر من زيادة الصادرات الكلية الزراعية وانه يجب العمل على زيادة فاعلية التأثير الإيجابي في الميزان التجاري بصفة عامة والميزان التجاري الزراعي بصفة خاصة. كما يجب التركيز على مستقبل التجارة الخارجية اليمنية والتعرف على التأثيرات المتوقعة نتيجة تطبيق اتفاقيات المنظمة والتعامل مع اهم الأسواق التي تؤثر في التجارة الخارجية اليمنية. واليمن من الدول الأقل نمواً حسب تقسيمات منظمة التجارة العالمية وبالإمكان الاستفادة من التسهيلات التي تعطى لهذه الشريحة على ان يتم ذلك على أساس دوري. واليمن لا يقوم بعملية دعم التصدير ويتوجب على اليمن ان تستمر في المطالبة بحقوقها في الاتفاقية الزراعية والذي يعطيها الحق في دعم التصدير. كما يجب على اليمن ان تدرس بعناية الاشرطيات الصحية الواردة في الاتفاقية الزراعية.

كما ذكر كليب(2008) انه قد لا يتحقق لليمن كل ما يصبو اليه من آثار إيجابية على الاقتصاد نتيجة انضمامه لمنظمة التجارة العالمية وتحرير بعض قطاعاته نظراً لمحدودية النشاط الاقتصادي وصغر حجم القطاع المالي وافتقار قطاع السياحة للعديد من خدمات البنية التحتية والخدمات المساعدة، فنتائج التحرير متباينة ومكاسبها مختلفة من دولة لأخرى وتعتمد بالأساس على تطور الاقتصاد وتنوع قاعدته الإنتاجية بالدول التي لديها تنوع في النشاط الاقتصادي

العديد من الاجراءات والقرارات الهادفة الى انضمام اليمن الى منظمة التجارة العالمية. فقد صدر قرار رئيس الحكومة رقم (239) لعام 1998 بإنشاء اللجنة الوطنية للإعداد والتفاوض مع منظمة التجارة العالمية. وبناءً على طلب الحكومة اليمنية، اقر المجلس العام للمنظمة في 14 ابريل 1999 قبول اليمن عضواً مراقباً، وفي 13 ابريل 2000 قدمت اليمن في جنيف طلب الانضمام الى سكرتارية المنظمة، وقُبل هذا الطلب في 17 يوليو 2000. وفي سبيل تطويع القوانين والقرارات المحلية لتتماشى مع إجراءات الانضمام لمنظمة التجارة العالمية، ففي عام 2001 تم اجراء تعديلات دستورية فيما يخص الجانب الاقتصادي. كما صدرت عدة قرارات جمهورية بالقانون متعلقة بتعديلات تخص قوانين التجارة الداخلية والتجارة الخارجية وقد كان منها اصدار القانون رقم (5) لسنة 2007 بشأن التجارة الداخلية وكذلك القانون رقم (16) لسنة 2007 بشأن التجارة الخارجية (حاميم، 2014).

وفي مجال السياسة النقدية وبعد الشروع بسياسة الإصلاح الاقتصادي قام البنك المركزي اليمني بإلغاء نظام سعر الصرف المتعدد في 1996 واعتمدت اليمن نظام تعويم صرف العملات. كما لم يفرض البنك المركزي اليمني أي قيود على التحويلات للعمليات الجارية، وقام بضمان التحويلات المالية من الأجنب الناتجة عن العمليات الخارجية. كما قامت الحكومة بمراجعة الكثير من القوانين للتأكد من توافقها مع متطلبات منظمة التجارة العالمية. وفي مجال تشجيع المنافسة صدر القانون رقم (19) لسنة 1999 والمتعلق بتشجيع المنافسة ومنع الاحتكار والغش التجاري. وتم انشاء هيئة حكومية لمكافحة الاحتكار وحماية المنافسة المخلافي (2002). كما قامت الحكومة بإصلاح نظام الجمارك ادارياً وقانونياً، وطبقت النظام الجمركي الآلي وعملت على تسهيل اجراءات الاستيراد والتصدير، اما في جانب الاستثمار، فان قانون الاستثمار اليمني رقم (15) لسنة 2010 وتعديلاته، تضمن مبدأ المعاملة الوطنية، ومبدأ عدم التمييز بين جميع جنسيات المستثمرين واستثماراتهم. وبذلك يكون قانون الاستثمار قد منح المستثمر الاجنبي حقوقاً وضمانات كبيرة (حاميم، 2014). اما في إطار الخدمات، فقد وضعت الحكومة اليمنية وفق قانون وكالات وفروع الشركات الاجنبية، الباب مُشرعاً امام المستثمرين الاجانب واستثماراتهم في مجالات أنشطة الخدمات المختلفة باستثناء أنشطة محدودة تتم الموافقة عليها من مجلس الوزراء. وفي اتجاه انضمام اليمن لمنظمة التجارة العالمية فقد اخذت اليمن نحو ثلاث عشر سنة من العمل الشاق والجهد الوطني المتواصل لتحقيق هدف الانضمام لمنظمة التجارة العالمية، وقد استمرت من العقد الأخير من القرن الماضي، وفي الاجتماع الوزاري التاسع لمنظمة التجارة العالمية في ديسمبر 2013 في جزيرة بالي بإندونيسيا تم خلاله اتخاذ قرار قبول طلب اليمن لعضوية المنظمة بالإجماع ومن قبل كافة أعضاء المنظمة ومع ختام مرحلة المفاوضات التي تعرضت لمرحلة من التفاوض طويلة ومعقدة وقد أصبحت اليمن العضو رقم (160)، وقد صدر القانون اليمني رقم (19)

### مشكلة البحث

يعاني اليمن من سنوات من أزمات اقتصادية أدت الى خلل في التجارة الخارجية وعائد ذلك الى انخفاض الصادرات، وقد سعت الى تهيئة البيئة الاقتصادية واتبعت سياسة الإصلاح الاقتصادي وعملت تعديلات تشريعية وقانونية وتنظيمية والتفاوض الشاق بهدف الانضمام لمنظمة التجارة العالمية فهل أدى ذلك الى تحسين كفاءة التجارة الخارجية لليمن، وهل تحققت منفعة في المجال التجاري من الانضمام للمنظمة؟

### فرضية البحث

تتمثل فرضية البحث في ان انضمام اليمن الى منظمة التجارة العالمية يؤثر على قطاع التجارة الخارجية.

## Materials & Method

### المواد وطرائق العمل

#### الطريقة البحثية

اعتمدت الدراسة على اسلوبي التحليل الوصفي والكمي للظواهر والمتغيرات الاقتصادية موضع الدراسة، مع استخدام طرق التحليل الاقتصادي والاحصائي لقياس تلك الظواهر والمتغيرات، وعلى وجه التحديد تم استخدام الأساليب البحثية الآتية: **معادلات الاتجاه الزمني العام:** في دراسة تطور التجارة الخارجية اليمنية بشقيها الصادرات والواردات وعجز الميزان التجاري وغيرها خلال فترتي الدراسة (2001-2013) و(2014-2018).

كما اعتمد البحث على العديد من مؤشرات كفاءة التجارة الخارجية وذلك لقياس كفاءة التجارة الخارجية اليمنية من خلال استخدام المؤشرات التالية:

- 1. مؤشر درجة الانكشاف الاقتصادي:** يمثل هذا المؤشر مدى أهمية الصادرات والواردات من الناتج المحلي الإجمالي، ويسمى أيضاً درجة الانفتاح الاقتصادي تعبيراً على مدى الانفتاح الاقتصادي للدولة على العالم الخارجي، ويدل ارتفاع هذا المؤشر على تأثير الاقتصاد تأثراً كبيراً بالتجارة الخارجية غير ان هذا لا يعني أنه ليس للتجارة الخارجية فوائد للمشاركة فيها ولكن يجب تجنب الاعتماد شبه الكلي للنشاط الاقتصادي القومي على التصدير والاستيراد، وارتفاع هذا المؤشر يدل على التبعية للخارج. ويتم حساب درجة الانكشاف الاقتصادي وفقاً للمعادلة التالية:  $\text{درجة الانكشاف الاقتصادي} = (\text{قيمة الصادرات} + \text{قيمة الواردات}) \div \text{قيمة الناتج المحلي الإجمالي} \times 100$
- 2. مؤشر معدل التغطية:** يشير هذا المعيار الى المركز التجاري للدولة، او كفاءة التجارة الخارجية للبلد ومعرفة مقدرتها على تغطية نفقات وارداتها الكلية من دخل الصادرات، وارتفاع هذا المؤشر عن 100 يدل ان قيمة صادرات البلد تكفي لتغطية قيمة وارداتها وان هناك فائضاً في الميزان التجاري. ويتم تقديره من خلال المعادلة التالية:  $\text{معدل التغطية} = (\text{قيمة الصادرات} \div \text{قيمة الواردات}) \times 100$ ، كما ذكر الموافي (2016).
- 3. مؤشر متوسط الميل للتصدير:** يدل هذا المؤشر على الوزن العائد لنشاط الصادرات في تكوين الناتج المحلي الإجمالي لاقتصاديات البلد، ويتم حسابه وفقاً للمعادلة التالية:  $\text{متوسط الميل للتصدير} = (\text{قيمة الصادرات} \div \text{قيمة الناتج المحلي الإجمالي}) \times 100$  كما ذكر سليمان (2016).
- 4. مؤشر متوسط الميل للاستيراد:** يوضح مدى اعتماد الدولة على الخارج ويقصد به مدى اعتماد البلد على توفير ما يحتاجه على الاستيراد من الخارج وهو عبارة عن نسبة ما تمثله قيمة

ومتطورة سياسياً واجتماعياً تستفيد أكثر من تلك التي تعاني من تخلف اقتصادي وسياسي واجتماعي. فلا يمكن الجزم وبصورة مطلقة ان نتائج تحرير أي من قطاعات الاقتصاد سيؤدي الى تطوير ذلك القطاع. فقد تتأثر العمالة المحلية سلباً من تحرير تجارة الخدمات. ولا شك ان هناك بعض الاثار الإيجابية التي سيجنيها الجهاز المصرفي اليمني في حالة انضمام اليمن لمنظمة التجارة العالمية. وأن المكاسب الحقيقية لتحرير تجارة الخدمات تفوق المكاسب الحقيقية لتحرير تجارة السلع. وإذا أراد اليمن ان يكون له مكانة على الساحة الإقليمية والدولية فعليه تحسين أوضاعه الاقتصادية معتمداً على موارده الذاتية وأن ينطلق من أسس وثوابت تهدف الى خلق تراكم رأسمالي وقاعدة إنتاجية متنوعة ومتطورة وليس تنفيذ ما يملبه الغير لنيل رضاهم، رغبة في الانضمام.

وفي دراسة للكهالي (2008) وبعد تحليل فرضيات الاثار السلبية والاييجابية ذكر ان قيم الاثار الإيجابية أكبر من قيم الاثار السلبية بفارق ضئيل الا انه يرى ان المحصلة النهائية ستكون لصالح الاثار الإيجابية عند الاستفادة من نتائج الدراسة. وانه من الأفضل انضمام اليمن الى المنظمة شرط ان تعمل اليمن بشكل دؤوب على تعظيم منافع الانضمام والتقليل من تكاليف الانعكاسات السلبية وهو امر ضروري يجب تذكره في كل جولة تفاوض لانضمام اليمن الى المنظمة.

كما ذكر السنيدار (2009) انه بعد الانضمام لمنظمة التجارة العالمية سيؤدي إلى مساعدة المنتجين والصناعيين اليمنيين في تطوير مشروعاتهم الاقتصادية، إضافة الى شحذ همم اليمنيين وإذكاء روح المنافسة في كل القطاعات التجارية، مما قد يفسح المجال أمام زيادة الصادرات اليمنية وزيادة الدخل القومي.

كما اشار اليماني (2014) الى ضيق الرقعة السوقية للصادرات اليمنية عامة وعلى وجه الخصوص النفطية والتي تمثل حوالي 90% من حجم الصادرات اليمنية، وأوصى بمحاولة البعد عن الاعتماد الشبه الكامل على النفط كسلعة او مكون رئيسي للصادرات كونه غير مستقر ويتأثر بالأسعار العالمية ويعتبر ثروة قابلة للنفاذ كما يجب إعادة النظر في الخارطة التصديرية والاستيرادية اليمنية في ضوء المتغيرات الدولية والمحلية حتى لا تتعرض لأي هزات تحدث في اقتصاديات تلك الدول التي لها علاقات تجارية مع اليمن.

وفي نشرة آفاق التجارة الدولية (غير معروف، 2006) ذكرت ان الحقيقة التي لا شك فيها هي ان الدول العربية التي تعتمد على الاستيراد الصافي للغذاء سوف تتحمل أعباء جديدة وازدادية في تأمين احتياجاتها الغذائية من الأسواق الخارجية. وهذا ينطبق في الواقع على معظم الدول العربية. وإذا استفادت بعض الدول من إزالة الدعم الزراعي ودعم الصادرات، مثل ارتفاع أسعار الخضروات والفواكه والمواهب فهي فوائد لا يقوم ولا ينهض عليها اقتصاد عربي قوي.

وفي الحقيقة نجد ان كل الدراسات السابقة تناولت توقعات واحتمالات لما سيكون عليه الوضع حال انضمام اليمن للمنظمة، وكانت توقعات البعض إيجابية واخرى سلبية بينما دراستنا تناولت دراسة الواقع الحالي للتجارة الخارجية وبعد انضمام اليمن للمنظمة، والبيانات فعلية وكانت النتائج من الواقع والحقيقة، وقد تزامنت الفترة الثانية بعد قبول انضمام اليمن، وتزامنت بوقوع اليمن في حرب وحصار.

أدى بلغ 569 مليار ريال عام 2001 وتزايدت لتصل إلى أقصاها عام 2013 لتبلغ حوالي 1563 مليار ريال أي أنها تضاعفت 1.7 مرة عن سنة 2001. ومن تقديرات الاتجاه العام من المعادلة (1) في الجدول (2) يتضح ان الزيادة السنوية اخذت اتجاه متزايد معنوي احصائي بلغت نحو 91.6 مليار ريال تمثل نحو 7.9% من المتوسط السنوي لقيمة الصادرات والبالغ 1158 مليار ريال للفترة الاولى.

ومن الجدول (1) يتبين ان قيمة الصادرات اليمنية الكلية في الفترة الثانية (2014-2018) فترة ما بعد قبول انضمام اليمن لمنظمة التجارة العالمية قد تراوحت ما بين حد أدنى بلغ 3.9 مليار ريال عام 2018 وهو عام نهاية الفترة الثانية، وحد أقصى بلغ 1419 مليار ريال عام 2014 في عام بداية الفترة الثانية. ومن تقديرات الاتجاه العام من المعادلة رقم (9) في الجدول (2) يتبين ان قيمة الصادرات اليمنية الكلية في الفترة الثانية قد تناقصت غير معنوي بمقدار سنوي حوالي 303 مليار ريال يمثل 85% من المتوسط السنوي لقيمة الصادرات للفترة الثانية والبالغ حوالي 354.2 مليار. كما يشير الجدول (1) والشكل (1) ان النقص في قيمة متوسط الصادرات للفترة الثانية عن قيمة متوسط صادرات الفترة الأولى بلغ حوالي 804 مليار ريال يمثل النقص حوالي 69% من متوسط صادرات الفترة الأولى. ويعزى ذلك إلى أثر الصراع والحرب والحصار الشامل والذي تعرضت له اليمن من مارس 2015 كما توقف انتاج النفط والغاز في العديد من القطاعات الاستخراجية وبسبب الاختلالات الأمنية ومغادرة معظم الشركات اليمنية.

**2. تطور قيمة الواردات الكلية اليمنية:** ومن بيانات الجدول (1) تشير ان قيمة الواردات الكلية اليمنية في فترة الدراسة الأولى (2001-2013) ما قبل قبول انضمام اليمن إلى منظمة التجارة العالمية قد تراوحت بين حد ادنى بلغ 416 مليار ريال عام 2001 سنة الأساس وحد أقصى بلغ حوالي 2888 مليار ريال عام 2013 أي ان قيمة الواردات قد تضاعفت حوالي 6 مرات خلال الفترة، ومن تقديرات الاتجاه العام من المعادلة (2) في الجدول (2) يتضح ان قيمة الواردات الكلية اليمنية قد تزايدت بمعدل معنوي احصائي بلغ 200 مليار ريال سنوياً يمثل 13.2% من متوسط الفترة الأولى والبالغ 1512 مليار ريال.

ومن الجدول (1) يتبين ان قيمة الواردات اليمنية الكلية خلال الفترة الثانية (2014-2018) ما بعد قبول انضمام اليمن لمنظمة التجارة العالمية قد تراوحت بين حد أدنى بلغ 828 مليار عام 2018 نهاية الفترة وما بين حد أقصى بلغ حوالي 3174 مليار عام 2014 اول الفترة الثانية. ومن تقديرات الاتجاه العام في المعادلة (10) في الجدول (2) يتبين ان قيمة الواردات الكلية اليمنية قد تناقصت سنوياً بمعنوية إحصائية عند 5% بحوالي 523 مليار ريال يمثل التناقص 31% من متوسط الفترة الثانية والبالغ 1668 مليار ريال. كما يشير الجدول (1) والشكل (1) ان زيادة قيمة متوسط واردات اليمن للفترة الثانية عن قيمته للفترة الأولى بلغ حوالي 156 مليار ريال تمثل الزيادة 10.3% من متوسط الفترة الأولى. ويتضح ان قيمة واردات اليمن ضلت مرتفعة رغم الحرب والحصار وراجع ذلك إلى اعتماد اليمن على الواردات من الخارج خاصة لتلبية احتياجاته من السلع الأساسية والضرورية كما مثلت المساعدات الإنسانية من المنظمات الدولية جزء كبير من تلك الواردات.

**3. تطور قيم الميزان التجاري اليمني:** ومن بيانات الجدول (1) تشير ان قيم الميزان التجاري اليمني في فترة الدراسة الأولى

الواردات الكلية إلى قيمة الناتج المحلي الإجمالي ويتم حساب هذا المؤشر وفقاً للمعادلة التالية: **متوسط الميل للاستيراد = (قيمة الواردات ÷ قيمة الناتج المحلي الإجمالي) × 100**

**5. مؤشر درجة التركيز السلعي للصادرات والواردات:** يوضح هذا المؤشر مدى اعتماد بلد ما في صادراته او وارداته على سلعة واحدة او عدد محدد من السلع ويبين هذا المؤشر نسبة ما تمثله صادرات او واردات السلع الرئيسية في هيكل الصادرات او الواردات للبلد وكلما ارتفعت قيمة المؤشر واقتربت من 100% دل على التركيز السلعي للصادرات او الواردات.

**6. مؤشر التركيز الجغرافي للصادرات:** يعبر هذا المؤشر على مدى تركيز صادرات الدولة في عدد محدود من الدول في التجارة الدولية، وترجع أهمية هذا المؤشر في العمل على تقليل المخاطر في فترات الأزمات والتنوع مطلوب لا في السلع فحسب بل في الأسواق المستوردة والمصدرة أيضاً ويمكن حساب هذا المؤشر من خلال المعادلة التالية: **التركيز الجغرافي للصادرات = (قيمة الصادرات إلى أهم بلدين أو ثلاث ÷ قيمة مجموع الصادرات) × 100** كما ذكر علي (2008).

**7. مؤشر التركيز الجغرافي للواردات:** يعبر هذا المؤشر عن مدى تركيز واردات دولة ما في عدد قليل من الدول في التجارة الدولية فإن ارتفاع هذا المؤشر يوضح حالة الضعف للدولة لأنه كلما ارتفع هذا المؤشر كلما دل على اقتصاد الدولة مكشوف لإجراءات عداثة من جانب الدول المصدرة له في حالة الازمات وخاصة إذا كانت السلع المستوردة ذات حساسية استراتيجية كالمواد الغذائية او المصنوعات. ويمكن حساب هذا المؤشر من خلال المعادلة التالي: **التركيز الجغرافي للواردات = (قيمة الواردات من أهم بلدين أو ثلاث ÷ قيمة مجموع الواردات) × 100**

### مصادر البيانات وفترة الدراسة

استند البحث بصفة رئيسية على البيانات المنشورة والغير منشورة للعديد من الجهات أهمها الجهاز المركزي للإحصاء بوزارة التخطيط (الجهاز المركزي للإحصاء 2019) وتقارير وزارة المالية وتقارير البنك المركزي اليمني وتقارير وزارة الصناعة والتجارة، وكما تم الاستعانة ببعض البحوث والدراسات المختلفة والمتصلة بموضوع البحث. ونتيجة للأوضاع التي حصلت لليمن من حرب وحصار وتوقف التصدير للسنوات الأخيرة وتعذر الحصول على البيانات بعد عام 2018 فقد اكتفى الباحث بدراسة فترة ما قبل قبول انضمام اليمن لمنظمة التجارة العالمية (2001-2013) وفترة ما بعد قبول انضمام اليمن للمنظمة (2014-2018).

### الهدف من البحث

يهدف البحث إلى استكشاف وضع التجارة الخارجية من خلال دراسة المؤشرات الاقتصادية لليمن وذلك خلال فترتي الدراسة قبل قبول اليمن كعضو في منظمة التجارة العالمية الفترة (2001-2013) والفترة التالية لقبول انضمام اليمن لمنظمة التجارة العالمية (2014-2018).

## Results & Discussion

### النتائج والمناقشة

#### 1. تطور قيمة الصادرات الكلية اليمنية

يتضح من الجدول (1) ان قيمة الصادرات الكلية اليمنية اخذت اتجاه متزايد خلال الفترة الأولى (2001-2013) قبل قبول انضمام اليمن لمنظمة التجارة العالمية، فقد تراوحت ما بين حد

**5. تطور عدد سكان اليمن:** من الجدول (1) يتضح تزايد اعداد السكان سنوياً وبزيادة كبيرة لا تعكسها ولا تجارياً قيم الناتج المحلي الإجمالي ولا قيم الصادرات والواردات. فقد بلغ معدل النمو السنوي للسكان في الفترة الأولى ما قبل قبول انضمام اليمن لمنظمة التجارة العالمية بلغ معدل النمو السكاني السنوي 3% وهو من اعلى المعدلات على مستوى العالم ورغم تراجع معدل النمو السكاني في الفترة الثانية والذي قدر بحوالي 2.7% سنوياً وهو ما يزال مرتفع رغم ما تعرضت له البلاد من حصار وحرب وأوضاع اقتصادية غير مناسبة. ويتقدير معدل النمو السكاني للفترة الكلية (2001-2018) فقد كان معدل النمو السكاني للفترة 2.9% سنوياً. وما يشهده اليمن من تزايد كبير في اعداد السكان يتوجب ان يواكب ذلك تطور في مختلف المجالات الاقتصادية والإنتاجية والخدمات والبنية التحتية وغيرها. ولكن الأرقام توضح غير ذلك، ومن بيانات الجدول (1) يتضح تواضع نصيب الفرد في اليمن من كلاً من الصادرات والواردات خلال سنوات الدراسة ما قبل وما بعد قبول انضمام اليمن للمنظمة.

#### مؤشرات قياس كفاءة التجارة الخارجية اليمنية

تبين هذه المؤشرات عن مدى كفاءة التجارة الخارجية اليمنية، وسوف يتم دراسة عدة مؤشرات لتوضح مدى كفاءة التجارة الخارجية اليمنية خلال الفترة الأولى فترة ما قبل قبول انضمام اليمن لمنظمة التجارة العالمية (2001-2013) ومقارنتها بالفترة الثانية وهي فترة ما بعد قبول انضمام اليمن لمنظمة التجارة العالمية (2014-2018).

1. **درجة الانكشاف الاقتصادي:** باحتساب درجة الانكشاف الاقتصادي ومن بيانات الجدول (3) تشير ان درجة الانكشاف الاقتصادي في فترة الدراسة الأولى (2001-2013) ما قبل قبول انضمام اليمن الى منظمة التجارة العالمية قد تراوحت بين حد أدنى بلغ 51.1% عام 2002 وحد أقصى بلغ حوالي 59.7% عام 2013، ومن تقديرات الاتجاه العام من المعادلة (1) في الجدول (4) يتضح ان درجة الانكشاف في الفترة الأولى كانت شبه مستقرة عند متوسط الفترة والمقدر 55% وهو مؤشر مرتفع خلال الفترة الأولى. ومن الجدول (3) يتبين درجة الانكشاف الاقتصادي خلال الفترة الثانية (2014-2018) ما بعد قبول انضمام اليمن لمنظمة التجارة العالمية قد تراوح بين حد أدنى بلغ 14.5% عام 2018 نهاية الفترة وما بين حد أقصى بلغ حوالي 64.3% عام 2014 اول الفترة الثانية وفي ذلك العام شهد اليمن استقرار اقتصادي وسياسي وتحسن كبير في التجارة الخارجية اليمنية والاقتصاد اليمني بشكل عام. ومن تقديرات الاتجاه العام في المعادلة (6) من الجدول (4) يتبين انها قد تناقصت سنوياً بمعنوية إحصائية عند 5% بحوالي 11.1 يمثل التناقص 33.5% من متوسط الفترة الثانية والبالغ 33%. كما يشير الجدول (3) والشكل (2) الى تناقص متوسط درجة الانكشاف الاقتصادي لليمن للفترة الثانية عن قيمته للفترة الأولى بحوالي 21.9 وليس راجع ذلك الى تحسن الاقتصاد اليمني ولكن يعزى ذلك الى ما تعرضت له اليمن من مارس 2015 من حرب وحصار شامل أدى الى تضرر القطاعات الاقتصادية العامة والخاصة كان من نتائجها تداعيات وتعطلت كثير من الأنشطة الاقتصادية والإنتاجية سببت خسائر في كل العالم الخارجي تصديراً واستيراداً

(2001-2013) ما قبل قبول انضمام اليمن الى منظمة التجارة العالمية قد تراوحت بين حد أدنى عجز بلغ 1326 مليار ريال عام 2013 وحد أقصى كفايض بلغ حوالي 153 مليار ريال عام 2001. ويتبين من الجدول ان الست السنوات الأولى من فترة الدراسة الأولى فقد حقق الميزان التجاري فائض سنوي أي ان قيمة واردات تلك السنوات كانت اقل من قيمة الصادرات، وبدء من عام 2007 وحتى نهاية فترتي الدراسة يتضح وجود عجزاً مستمر. ومن تقديرات الاتجاه العام من المعادلة (4) في الجدول (2) يتضح ان العجز خلال الفترة الأولى يتزايد بمعنوية سنوياً بحوالي 108 مليار ريال وقدر متوسط العجز للفترة الأولى بحوالي 354 مليار ريال، ومن الجدول (1) والشكل (1) يتبين ان الميزان التجاري خلال الفترة الثانية (2014-2018) ما بعد قبول انضمام اليمن لمنظمة التجارة العالمية قد استمر في عجز سنوي الى نهاية الفترة ويرجع تراجع قيم العجز في السنوات الأخيرة من سنوات الفترة الثانية الى انخفاض كلاً من الصادرات والواردات معاً. ويشير الجدول والشكل الى ان متوسط العجز في الميزان التجاري للمرحلة الثانية قد تزايد عن متوسط العجز للفترة الأولى بحوالي 960 مليار ريال. وهو ما يؤكد على استمرار الاستيراد لتغطية الاحتياجات الضرورية.

4. **تطور الناتج المحلي الإجمالي:** توضح بيانات الجدول (1) ارتفاع قيمة الناتج المحلي الإجمالي الاسمي لليمن (بالأسعار الجارية) فقد اخذ اتجاه متزايد خلال الفترة الأولى (2001-2013) قبل قبول انضمام اليمن لمنظمة التجارة العالمية، فقد تراوح ما بين حد أدنى بلغ 1896 مليار ريال عام 2001 وتزايد ليصل الى أقصاه عام 2013 ليلعب حوالي 7459 مليار ريال أي انه تضاعف أكثر من 2.9 مرة عن سنة الاساس. ومن تقديرات الاتجاه العام من المعادلة (5) في الجدول (2) يتضح ان الزيادة السنوية اخذت اتجاه متزايد معنوي احصائي بلغت نحو 508 مليار ريال وتمثل نحو 10.6% من المتوسط السنوي لقيمة الناتج المحلي الإجمالي والبالغ 4812 مليار ريال للفترة الأولى. ومن الجدول (1) والشكل (1) يتبين ان قيمة الناتج المحلي الإجمالي الاسمي لليمن (بالأسعار الجارية) في الفترة الثانية (2014-2018) فترة ما بعد قبول انضمام اليمن تراوح ما بين حد أدنى بلغ 5190 مليار ريال عام 2017، وحد أقصى بلغ 7140 مليار ريال عام 2014 في عام بداية الفترة الثانية رغم تدهور قيمة الريال اليمني امام العملات الأجنبية.

ومن تقديرات الاتجاه العام من المعادلة (13) في الجدول (2) يتبين ان القيمة في الفترة الثانية قد تناقصت غير معنوي بمقدار سنوي حوالي 336 مليار ريال يمثل 5.8% من المتوسط السنوي لقيمة الناتج المحلي الإجمالي الاسمي (بالأسعار الجارية) والبالغ حوالي 5821 مليار. ويتضح من تدهور ونقص قيم الناتج المحلي الإجمالي بالأسعار الجارية وخاصة في الفترة الثانية وهو ما يدل على تعرض الاقتصاد اليمني لتدهور كبير وخاصة لو تم التقدير بقيم الناتج المحلي الإجمالي الحقيقي. ويعزى ذلك الى ما تعرضت له اليمن من مارس 2015 من حرب وحصار شامل أدى الى تضرر القطاعات الاقتصادية العامة والخاصة كان من نتائجها تداعيات وتعطلت كثير من الأنشطة الاقتصادية والإنتاجية سببت خسائر في كل المجالات.

الثانية حوالي 5.2%. ومن تقديرات الاتجاه العام ومن المعادلة (8) في الجدول (4) يتضح ان الميل للتصدير تناقص في الفترة الثانية تناقص سنوي بلغ 4.30 مثل حوالي 82.01% من متوسط الفترة. ومن الجدول (3) والشكل (2) وهو ما يدل على التناقص السنوي الكبير في قيمة الصادرات خلال سنوات الفترة الثانية وعائد ذلك لما تعرضت له البلاد من حرب داخلية وخارجية وحصار اقتصادي.

4. **الميل للاستيراد:** وهو مؤشر يوضح مدى اعتماد الدولة على الواردات من العالم الخارجي لسد احتياجاتها. ومن بيانات الجدول (3) يتبين ان درجة الميل للاستيراد خلال الفترة الأولى فترة ما قبل قبول انضمام اليمن لمنظمة التجارة العالمية (2001-2013) تراوحت بين حد أدنى بلغ 21.9% عام 2001 وحد أقصى بلغ 38.7% عام 2013، ومن تقديرات الاتجاه العام ومن المعادلة (4) في الجدول (4) يتضح ان مؤشر الميل للاستيراد قد تزايد بمعنوية إحصائية عند 1% وبتزايد سنوي حوالي 1.08 مثل التزايد حوالي 3.36% سنوياً من متوسط الفترة الأولى والمقدر بحوالي 29.8%. كما تبين بيانات الجدول (3) مؤشرات الميل للاستيراد خلال الفترة الثانية (2014-2018) ما بعد قبول انضمام اليمن لمنظمة التجارة العالمية ان مقياس الميل للاستيراد في الفترة الثانية تراوح بين حد أدنى بلغ 14.5% عام 2018 وحد أقصى بلغ 44.5% عام 2014 وبلغ متوسط الفترة الثانية حوالي 27.8%. ومن تقديرات الاتجاه العام ومن المعادلة (9) في الجدول (4) يتضح ان الميل للاستيراد تناقص في الفترة الثانية تناقص سنوي معنوي عند 5% وبلغ التناقص 6.77 مثل حوالي 24.35% من متوسط الفترة الثانية.

ومن بيانات الجدول (3) والشكل (2) ومعادلات الجدول (4) يتضح ان مؤشر الميل للتصدير خلال السنوات الأولى من عام 2001-2006 كانت اعلى من مؤشرات الميل للاستيراد وبتزايد سنوي بلغ 2007 تغير الوضع حيث اصبح مؤشر الميل للاستيراد اعلى واكبر من مؤشر الميل للتصدير الى نهاية المرحلة الأولى وحتى السنوات الأخيرة من فترتي الدراسة الأولى والثانية، ورغم ما تعرضت له اليمن من حصار وحروب خاصة في سنوات الفترة الثانية الا ان مؤشر الميل للاستيراد رغم انه اخذ يتناقص الا ان مؤشر الميل للاستيراد ظل مرتفع وهو ما يوضح اعتماد اليمن على الواردات من الخارج وذلك لسد الاحتياجات المتعددة وهو ما يدل على تبعية اليمن للخارج وهو ما يستوجب الحل للمشاكل السياسية والاقتصادية والعمل على زيادة الصادرات وبمعدل اعلى من الواردات لتحسين الميزان التجاري لليمن.

5. **درجة التركيز السلي:** سيتم توضيحها من حيث درجة التركيز السلي للصادرات وكذلك درجة التركيز السلي للواردات: (أ) **درجة التركيز السلي للصادرات:** حيث يتضح من الجدول (3) والجدول (5) ان اليمن تعتمد في صادراتها على عدد محدود من السلع وتتمثل في صادرات اليمن من الوقود المعدني وزيتوت التشحيم والمواد المرتبطة به ومن الجدول يتبين ان نسبة صادراته خلال الفترة الأولى (2001-2013) فترة ما قبل قبول انضمام اليمن لمنظمة التجارة العالمية ومن المعادلة (5) من

2. **معدل التغطية:** يتضح من بيانات الجدول (3) ان معدل تغطية الصادرات الكلية اليمنية للواردات الكلية اليمنية تراوحت بين حد أدنى بلغ 54.1% في عام 2013، وحد أقصى بلغ 136.8% في عام 2001 في بداية الفترة الأولى فترة ما قبل قبول انضمام اليمن لمنظمة التجارة العالمية (2001-2013) كما يتضح من مؤشرات مقياس معدل التغطية للسنوات من عام 2001 حتى عام 2006 كانت قيم المؤشر اكثر من 100% وهو ما يوضح ان قيمة صادرات اليمن الكلية اكبر من قيمة واردات اليمن الكلية ويدل على ان الست السنوات الأولى من الفترة الأولى كان الميزان التجاري لليمن موجب كون معدل التغطية اكثر من 100% ويؤكد ان التجارة الخارجية توفر لليمن عملة اجنبية تستخدم في تمويل التنمية الشاملة، وقد بلغ متوسط معدل تغطية الصادرات الكلية اليمنية للواردات الكلية اليمنية خلال تلك الفترة نحو 87.9%، كما يتبين من بيانات الجدول (3) والمعادلة (2) من الجدول (4) يتبين ان مؤشرات تغطية الصادرات للواردات تناقص سنوياً معنوي احصائياً بحوالي 5.85 ويمثل التناقص 6.66% من متوسط الفترة الأولى. ومن الجدول (3) يتبين درجة تغطية الصادرات الكلية للواردات الكلية خلال الفترة الثانية (2014-2018) ما بعد قبول انضمام اليمن لمنظمة التجارة العالمية قد تراوحت بين حد أدنى بلغ 0.5% عام 2018 نهاية الفترة وما بين حد أقصى بلغ حوالي 44.7% عام 2014 اول الفترة الثانية وفي ذلك العام شهد اليمن استقرار اقتصادي وسياسي وتحسن كبير في التجارة الخارجية اليمنية والاقتصاد اليمني بشكل عام. ومن تقديرات الاتجاه العام في المعادلة (7) من الجدول (4) يتبين انها قد تناقصت سنوياً بمعنوية إحصائية عند 5% بحوالي 10.3 يمثل التناقص 73.86% من متوسط الفترة الثانية والبالغ 13.6%. كما يشير الجدول (3) والشكل (2) الى تناقص متوسط درجة تغطية الصادرات للواردات للفترة الثانية عن قيمته للفترة الأولى بحوالي 73.3 راجع ذلك الى ما تعرضت له اليمن من مارس 2015.

3. **الميل للتصدير:** وهو يبين درجة أهمية الصادرات الكلية الى الناتج المحلي الإجمالي، وتوضح بيانات الجدول (3) ان درجة الميل للتصدير خلال الفترة الأولى فترة ما قبل قبول انضمام اليمن لمنظمة التجارة العالمية (2001-2013) تراوحت بين حد أدنى بلغ 20.9% عام 2013 وحد أقصى بلغ 30% عام 2001، ومن تقديرات الاتجاه العام ومن المعادلة (3) في الجدول (4) يتضح ان مؤشر الميل للتصدير قد تناقص بمعنوية إحصائية وبتناقص سنوي حوالي 0.74 مثل التناقص حوالي 3% سنوياً من متوسط الفترة والمقدر بحوالي 25.2%.

كما توضح بيانات الجدول (3) مؤشرات الميل للتصدير خلال الفترة الثانية (2014-2018) ما بعد قبول انضمام اليمن لمنظمة التجارة العالمية ان مقياس الميل للتصدير في الفترة الثانية تراوح بين حد أدنى بلغ 0.1% عام 2018 وحد أقصى بلغ 19.9% عام 2014 وبلغ متوسط الفترة

الدراسة. ومن بيانات الجدول (3) يتبين ان اغلب سنوات الفترة الأولى كانت نسبة التركيز الجغرافي لأهم دولتين أكثر من 40% لكل سنوات الفترة الأولى ما عدى عام 2001 كان التركيز الجغرافي فيها 36.7%. كما تشير بيانات الجدول (3) ان اهم شريك تجاري في بداية الفترة الثانية (2014-2018) كانت الصين فقد ارتبطت اليمن بعقود تجارية كبيرة مع الصين، ولكن بدءاً من عام 2015 حتى نهاية الفترة الثانية فقد دخلت دول الجوار السعودية وعمان كمنفذ ومقصد لصادرات اليمن. وعائد ذلك لظروف الحرب والحصار التي تعرضت له اليمن.

**(ب): التركيز الجغرافي للواردات:** حيث يتضح من الجدول (3) ان اليمن تعتمد في وارداتها على الدول العربية المجاورة ويتبين في فترة الدراسة الأولى (2001-2013) ما قبل قبول انضمام اليمن الى منظمة التجارة العالمية كانت الامارات العربية المتحدة كأهم مصدر لواردت اليمن خلال كل سنوات الفترة الأولى رغم ان منشأ تلك الواردات دول أخرى، واتت السعودية في المرتبة الثانية ولمدة احدى عشر سنة خلال الفترة الأولى وظهرت الصين وهولندا كلا منهما في احدى سنوات الفترة الأولى ضمن اهم دولتين تورد لليمن. وقد تراوحت نسبة التركيز الجغرافي خلال الفترة الأولى ما بين 23% والى 31%. كما تشير بيانات الجدول (3) ان اهم شريك تجاري في بداية الفترة الثانية ما بعد قبول انضمام اليمن الى منظمة التجارة العالمية (2014-2018) كانت الصين فقد ارتبطت اليمن بعقود تجارية كبيرة مع الصين في جانبي الصادرات والواردات، ولكن بدءاً من عام 2015 حتى نهاية الفترة الثانية فقد دخلت دول الجوار والمتمثلة بالسعودية والامارات وعمان كمنفذ ومقصد لواردات اليمن. وعائد ذلك كذلك لظروف الحرب والحصار التي تعرضت له اليمن.

#### الاستنتاجات والتوصيات

وفي ضوء النتائج لهذه الدراسة خلص الباحث الى عدد من الاستنتاجات التي تشير الى انخفاض كفاءة التجارة الخارجية اليمنية بعد قبول انضمام اليمن للمنظمة وتدهورت الصادرات بل توقفت في السنوات الأخيرة للفترة الثانية وكانت الإجابة على فرضية البحث ولكن تأثير سلبي، فقد اتضح انخفاض متوسط الصادرات للفترة الثانية عما كان عليه كمتوسط للفترة الأولى، بينما تزايد متوسط الواردات في الفترة الثانية وكان من نتاج زيادة الواردات ارتفاع عجز الميزان التجاري في الفترة الثانية رغم ظروف البلد.

كما نستنتج ان متوسط معظم المتغيرات الاقتصادية في الفترة الثانية قد تناقصت مثل الصادرات واجمالي التجارة الخارجية والميزان التجاري ونصيب الفرد من الصادرات والواردات، ولم يحدث تحسن في كفاءة التجارة الخارجية. بينما تزايد متوسط الفترة الثانية عن متوسط الفترة الأولى لكل من الواردات والنتاج المحلي والأسعار الجارية وعدد السكان.

ومن دراسة مؤشرات كفاءة التجارة الخارجية اليمنية بين متوسط الفترة الثانية ومقارنتها بمتوسط الفترة الأولى نستنتج مؤشر الانكشاف الاقتصادي او الانفتاح الاقتصادي في

الجدول (4) وقد بلغت نسبة صادرات الوقود والمواد المرتبطة به كحد ادنى ما نسبته 79.9% من نسبة صادرات اليمن الاجمالية في عام 2013 وكحد اقصى بلغ ما نسبته 94.4% عام 2001 ومن معادلة الاتجاه العام فقد انخفضت النسبة للصادرات من الوقود المعدني والمواد المرتبطة به بصورة معنوية وبتناقص سنوي حوالي 0.93 ويمثل التناقص حوالي 1.06% من المتوسط للفترة والمقدر بحوالي 88.9%. ومن الجدول (3) والجدول (5) والشكل (3) ولدراسة مؤشر نسبة صادرات الوقود المعدني والمواد المرتبطة به خلال الفترة الثانية (2014-2018) كما يتضح من ان نسبة صادرات الوقود المعدني والمواد المرتبطة به مثلت ما نسبته 79% من صادرات اليمن الكلية في عام 2014 بينما توقف تصدير الوقود والمواد المرتبطة به في السنوات الثلاث الأخيرة للفترة الثانية. وفي المقابل تزايدت نسبة صادرات اليمن من المواد الغذائية والحيوانات الحية حيث كانت تمثل 5% كمتوسط للفترة الأولى لتترايد الى ما نسبته 57% كمتوسط للفترة الثانية وقد كانت اغلبها من الأسماك والقشريات والخضروات والفواكه والعسل والحبوب.

**(ب): درجة التركيز السلعي للواردات:** حيث يتضح من الجدول (6) والشكل (4) ان متوسط نسبة واردات اليمن من المواد الغذائية والحيوانات الحية المخصصة للأكل للفترة الأولى (2001-2013) كانت حوالي 25.2% وقد تزايدت النسبة كمتوسط للفترة الثانية الى 35.9% من اجمالي واردات اليمن. واتت واردات اليمن من الوقود المعدني وزيتو التشحيم والمواد المرتبطة به حيث مثلت ما نسبته 21.6% كمتوسط لواردات اليمن للفترة الأولى ولزيادة الى ما نسبته 23.2% كمتوسط لواردات اليمن للفترة الثانية.

كما مثلت واردات اليمن من الأجهزة الالية ووسائل النقل حيث كانت تمثل 21.7% من واردات اليمن كمتوسط للفترة الأولى ونقصت النسبة لتصل الى 12.8% كمتوسط للفترة الثانية من واردات اليمن.

**6. التركيز الجغرافي:** يعتبر هذا المؤشر في جانبيين الصادرات عن مدى تركيز صادرات اليمن الى عدد محدود من الدول وفي جانب الواردات يعبر عن مدى تركيز واردات اليمن من عدد قليل من الدول.

**(أ): التركيز الجغرافي للصادرات:** حيث يتضح من الجدول (3) ان اليمن تعتمد في صادراتها على عدد محدود من الدول ومن الجدول يتبين في فترة الدراسة الأولى (2001-2013) ما قبل قبول انضمام اليمن الى منظمة التجارة العالمية وكون صادرات اليمن تتمثل في الوقود المعدني والمواد المرتبطة به وبدراسة أهمية أكبر دولتين من حيث قيمة صادرات اليمن خلال الفترة فقد كانت الصين اهم دولة كشريك من حيث توجه صادرات اليمن اليها لكل سنوات الفترة الأولى باستثناء عام 2002 رغم ان هناك صادرات للصين ذلك العام لكنها لم تكن ضمن اهم دولتين. وكان اهم شريك بعد الصين هي تايلاند فقد كانت كثاني أهم دول تستورد من اليمن ولمدة ثمان سنوات خلال الفترة الأولى بينما كان الشريك الثالث من حيث أهميته كمتسورد من اليمن كانت الهند ولمدة ست سنوات خلال الفترة الأولى من



أعقبت تاريخ قبول انضمام اليمن لمنظمة التجارة العالمية باعتبارها من الدول الأقل نمواً.

ووفقاً لهذه الاستنتاجات نستخلص التوصيات التالية:

- ضرورة المصالحة الوطنية وانهاء الحرب والعمل مع المجتمع الدولي لإزالة الآثار وتحسين الوضع الاقتصادي والتجاري لليمن.
- إعادة النظر في السياسة المتبعة في مجال التجارة الخارجية بشقيها الصادرات والواردات والعمل بما هو في مصلحة اليمن، والعمل على زيادة الصادرات وترشيد الواردات.
- الاستفادة من الاتفاقيات المختلفة العربية والعالمية والتكتلات والعمل على زيادة الصادرات وتقليل الواردات.
- التباحث والتفاوض مع الجهات المختصة بمنظمة التجارة العالمية واعتبار الفترة التي تعرضت لها اليمن من حرب وحصار وقلاقل لا تؤثر على الميزات التي كانت اليمن موعودة بها.

#### الشكر والعرفان

يتقدم الباحث بجزيل الشكر والعرفان الى القائمين في البنك المركزي اليمني، الجهاز المركزي للإحصاء، الإدارة العامة للتجارة الخارجية، وزارة التخطيط لما بذلوا من تدليل الصعاب وتقديم المساعدة خلال تجميع البيانات واجراء هذه الدراسة.

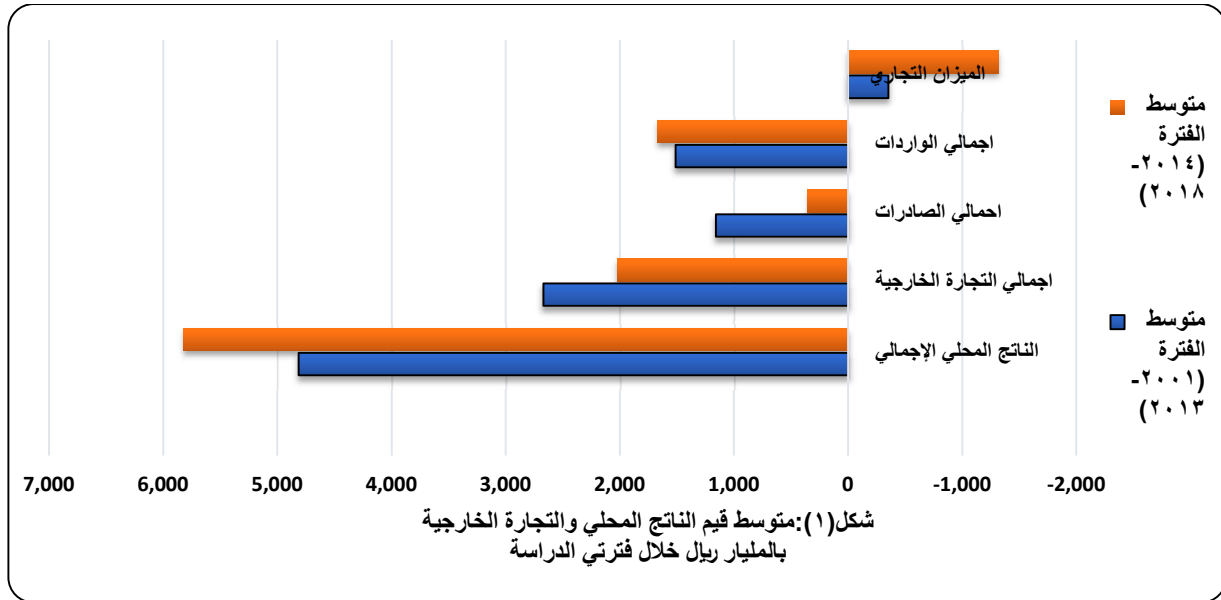
الفترة الثانية تناقص عما كان عليه كمتوسط للفترة الأولى وليس عائد ذلك الى تحسن التجارة ولكن الى ما تعرضت له اليمن من حصار وحرب تزامنت مع الفترة الثانية. كما تناقص متوسط معدل تغطية الصادرات للواردات للفترة الثانية عن الفترة الأولى. وتناقص متوسط الميل للتصدير عن الفترة الأولى. بينما كان متوسط تناقص الميل للاستيراد للفترة الثانية عن الأولى بنسبة بسيطة رغم ظروف الحرب وبحوالي 2% وهو ما يبرهن التبعية الاقتصادية للخارج لتغطية الاحتياجات السكانية من السلع والخدمات. كما تبين ارتفاع درجة التركيز الجغرافي للصادرات في الفترة الأولى مع دول الصين وتايلاند، وتمثلت صادرات الوقود المعدني وزيتون التشحيم والمواد المتصلة بها كمتوسط للفترة الأولى حوالي 88%. بينما اول سنتين في الفترة الثانية تركز التصدير الى الصين وكوريا الجنوبية وتمثلت صادرات الوقود المعدني والمواد المتصلة به بحوالي 64% وتوقف التصدير في السنوات الأخيرة للفترة الثانية. كما تبين تركيز واردات اليمن خلال سنوات فترتي الدراسة واعتبار دولي الامارات والسعودية كمصدر للمستوردات.

تبين ان اليمن لم تستفيد من توفير بعض الفترات الزمنية الانتقالية لتنفيذ بعض اتفاقيات والتزامات منظمة التجارة العالمية كما لم تستفيد من أي مميزات وعود ومنح وتسهيلات وهبات كانت ستقدم في اثناء الفترة الانتقالية والتي

جدول (1): الصادرات والواردات الإجمالي والميزان التجاري لليمن مليار ريال خلال الفترة (2001-2018)

السنوات	احمالي الصادرات	اجمالي الواردات	اجمالي التجارة الخارجية	الميزان التجاري	الناتج المحلي الإجمالي	متوسط نصيب الفرد من الصادرات ألف ريال	متوسط نصيب الفرد من الواردات ألف ريال	عدد السكان ألف نسمة
2001	569.0	415.9	984.9	153.1	1,896.0	32.1	23.4	17,742
2002	585.9	513.0	1,099.0	72.9	2,151.0	32.0	28.1	18,283
2003	684.9	674.2	1,359.1	10.7	2,487.0	36.4	35.8	18,841
2004	750.2	741.8	1,492.0	8.4	2,886.0	38.6	38.2	19,414
2005	1,068.5	1,029.9	2,098.4	38.6	3,647.0	53.5	51.5	19,983
2006	1,309.7	1,196.9	2,506.5	112.8	4,495.0	63.6	58.1	20,590
2007	1,247.3	1,693.9	2,941.2	-446.6	5,100.0	58.8	79.9	21,209
2008	1,519.3	2,087.9	3,607.2	-568.6	6,072.0	69.6	95.6	21,844
2009	1,268.4	1,861.7	3,130.0	-593.3	5,772.9	56.4	82.8	22,492
2010	1,451.4	2,095.1	3,546.5	-643.7	6,843.9	62.7	90.5	23,154
2011	1,523.8	2,037.4	3,561.2	-513.6	6,714.9	63.9	85.5	23,833
2012	1,514.1	2,421.4	3,935.5	-907.3	7,037.3	61.7	98.7	24,527
2013	1,562.5	2,888.2	4,450.7	-325.7	7,459.0	61.9	114.5	25,235
2014	1,419.4	3,174.3	4,593.7	-754.9	7,140.0	54.7	122.3	25,956
2015	222.3	1,526.8	1,749.1	-304.5	5,729.0	8.3	57.2	26,687
2016	98.3	1,826.4	1,924.7	-728.1	5,317.0	3.6	66.6	27,426
2017	27.3	986.3	1,013.6	-959.0	5,190.0	1.0	35.0	28,170
2018	3.9	828.2	832.1	-824.3	5,731.0	0.1	28.6	28,918
متوسط الفترة (2001-2013)	1,158.1	1,512.1	2,670.2	-354.0	4,812.5	53.2	67.9	21,319.0
متوسط الفترة (2014-2018)	354.2	1,668.4	2,022.6	-1,314.2	5,821.4	13.5	62.0	27,431.4

المصدر: كتاب الإحصاء السنوي، اعداد متفرقة، الجهاز المركزي للإحصاء وزارة التخطيط، الجمهورية اليمنية.



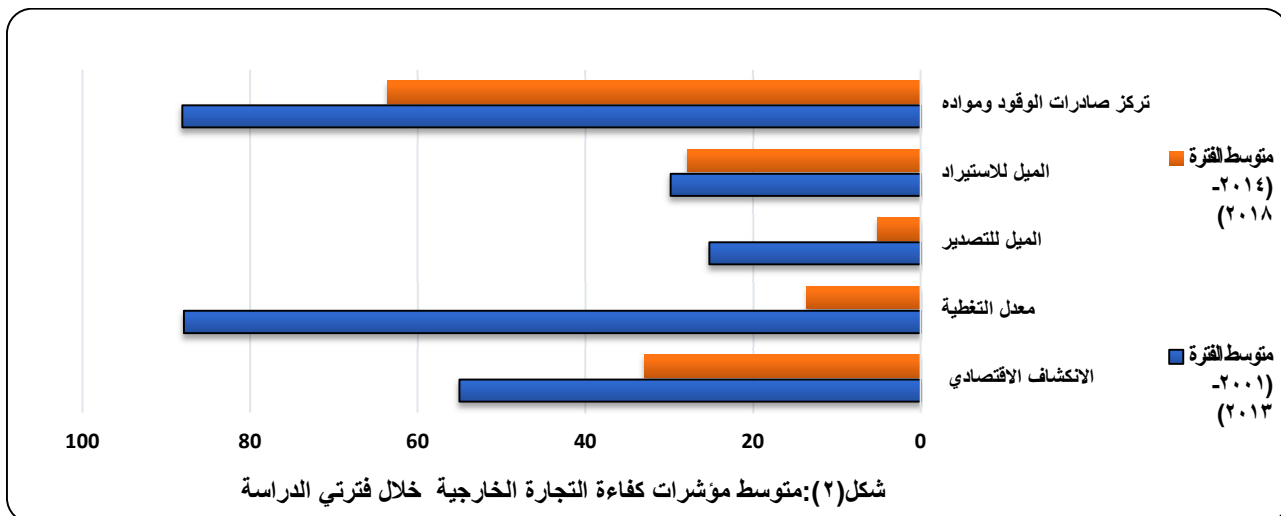
م	البيان	مقدار التغير السنوي	الانحدار-	معدل التغير السنوي	معامل التحديد	قيمة (T)	قيمة (F)
الفترة الأولى (2013-2001)							
1	اجمالي الصادرات مليار ريال	91.59		7.91	0.86	**8.56	**73.22
2	اجمالي الواردات مليار ريال	200.24		13.24	0.95	**15.08	**227.38
3	اجمالي التجارة الخارجية مليار ريال	291.83		10.93	0.95	**14.92	**222.72
4	الميزان التجاري مليار ريال	-108.64		30.69	0.83	** -7.97	**59.18
5	الناتج المحلي الإجمالي مليار ريال	507.82		10.55	0.97	**18.4	**338.73
6	متوسط نصيب الفرد من الصادرات ألف ريال	0.24		0.45	0.69	**4.97	**24.73
7	متوسط نصيب الفرد من الواردات ألف ريال	0.12		0.18	0.92	**11.63	**135.32
8	عدد السكان ألف نسمة	0.0016		0.0000	0.998288	**80.1	**6416.04
الفترة الثانية (2018-2014)							
9	اجمالي الصادرات مليار ريال	-302.61		-85.42	0.63	-2.27	5.17
10	اجمالي الواردات مليار ريال	-523.27		-31.36	0.79	*-3.32	*11.01
11	اجمالي التجارة الخارجية مليار ريال	-825.87		-40.83	0.75	*-2.98	8.86
12	الميزان التجاري مليار ريال	220.66		-16.79	0.67	*2.44	5.97
13	الناتج المحلي الإجمالي مليار ريال	-335.70		-5.77	0.47	-1.62	2.64
14	متوسط نصيب الفرد من الصادرات ألف ريال	-0.05		-0.40	0.63	-2.25	5.08
15	متوسط نصيب الفرد من الواردات ألف ريال	-0.04		-0.06	0.80	*-3.41	*11.64
16	عدد السكان ألف نسمة	386.2916		1.41	1.00	**386.29	**149221.1

المصدر: حسب من الجدول (1)، \*\* معنوي عند 1% \* معنوي عند 0.05 = P

جدول (3): تطور مؤشرات كفاءة التجارة الخارجية اليمنية خلال الفترة من (2001-2018)

السنوات	الانكشاف الاقتصادي درجة الانفتاح الاقتصادي	معدل التغطية	الميل للتصدير	الميل للاستيراد	درجة التركيز السلعي للصادرات ووقود معدني ومواد متصلة به	التركيز الجغرافي للصادرات %	الدولتان الرئيسيتان للصادرات	التركيز الجغرافي للواردات %	الدولتان الرئيسيتان كمصدر للواردات
2001	51.9	136.8	30.0	21.9	94.36	36.7	الصين والهند	24.9	الامارات والسعودية
2002	51.1	114.2	27.2	23.9	90.50	45.8	تايلاند والهند	28.6	الامارات والسعودية
2003	54.6	101.6	27.5	27.1	90.32	54.7	الصين وتايلاند	25.2	الامارات والسعودية
2004	51.7	101.1	26.0	25.7	91.17	57.6	تايلاند والصين	25.5	الامارات والسعودية
2005	57.5	103.7	29.3	28.2	91.57	51.5	الصين والهند	27.4	الامارات والسعودية
2006	55.8	109.4	29.1	26.6	91.64	46.5	الهند والصين	31.7	الامارات والسعودية
2007	57.7	73.6	24.5	33.2	88.78	40.4	الصين وتايلاند	29.8	الامارات والسعودية
2008	59.4	72.8	25.0	34.4	87.25	54.9	الصين وتايلاند	35.9	الامارات والسعودية
2009	54.2	68.1	22.0	32.2	89.04	45.2	الصين والهند	25.4	الامارات والصين
2010	51.8	69.3	21.2	30.6	87.79	54.1	الهند والصين	27.4	الامارات والسعودية
2011	53.0	74.8	22.7	30.3	86.26	50.1	الصين وتايلاند	26.3	الامارات والسعودية
2012	55.9	62.5	21.5	34.4	86.95	60.1	الصين وتايلاند	23.2	الامارات وهولندا
2013	59.7	54.1	20.9	38.7	79.85	42.3	الصين وتايلاند	31.0	الامارات والسعودية
2014	64.3	44.7	19.9	44.5	78.39	51.6	الصين وكوريا الجنوبية	17.7	الامارات والصين
2015	30.5	14.6	3.9	26.6	48.78	51.3	كوريا الجنوبية والسعودية	25.1	السعودية والامارات
2016	36.2	5.4	1.8	34.4	0.31	73.8	السعودية وعمان	32.0	الامارات والسعودية
2017	19.5	2.8	0.5	19.0	0.00	67.8	عمان والسعودية	34.1	عمان والامارات
2018	14.5	0.5	0.1	14.5	0.00			34.9	الامارات وعمان
متوسط الفترة (2001-2013)	55.0	87.9	25.2	29.8	88.1				
متوسط الفترة (2014-2018)	33.0	13.6	5.2	27.8	63.6				

المصدر: حسب من بيانات الجدول (1)، وجداول أخرى.

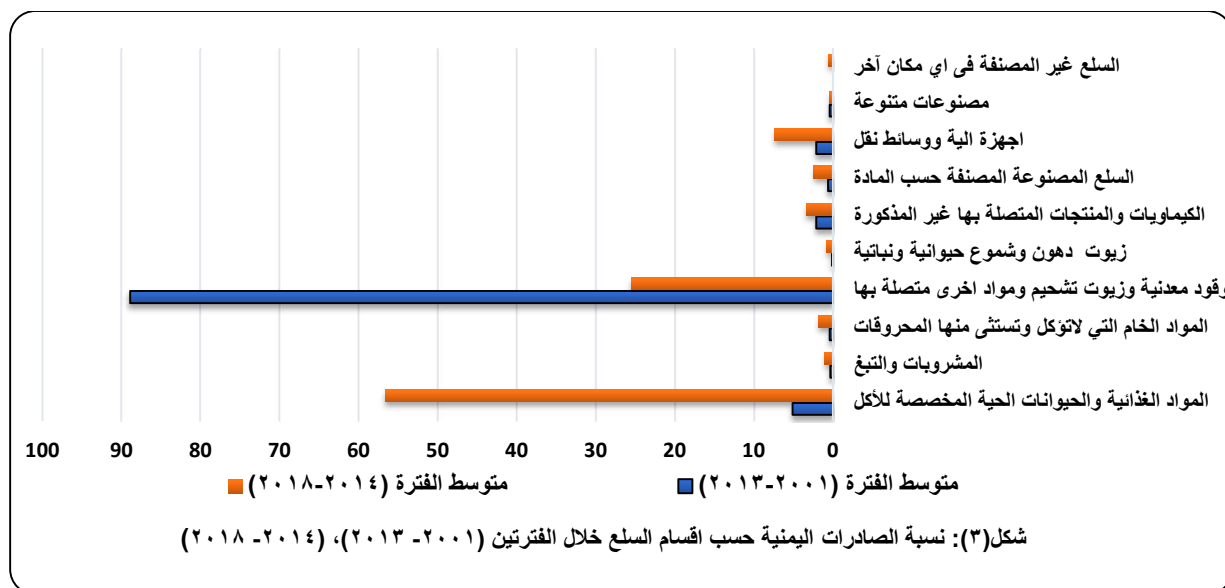


جدول (4): الاتجاه العام لتطور مؤشرات كفاءة التجارة الخارجية اليمنية خلال الفترتين (2013-2001)، (2018-2014)						
م	البيان	الانحدار-مقدار التغير السنوي	معدل التغير السنوي	معامل التحديد	قيمة (T)	قيمة (F)
الفترة الأولى(2013-2001)						
1	الانكشاف الاقتصادي درجة الانفتاح الاقتصادي	0.34	0.61	0.19	1.63	2.66
2	معدل التغطية	-5.85	-6.66	0.86	** -8.07	**65.09
3	الميل للتصدير	-0.74	-2.96	0.77	** -6.12	**37.43
4	الميل للاستيراد	1.08	3.63	0.78	**6.19	**38.35
5	درجة التركيز السلعي للصادرات وقود معدني ومواد متصلة به	-0.93	-1.06	0.72	** -5.32	**28.35
الفترة الثانية(2014- نهاية البيانات المتوفرة)						
6	الانكشاف الاقتصادي درجة الانفتاح الاقتصادي	-11.06	-33.50	0.80	* -3.51	*12.35
7	معدل التغطية	-10.03	-73.86	0.76	* -3.07	9.41
8	الميل للتصدير	-4.30	-82.01	0.67	* -2.46	6.03
9	الميل للاستيراد	-6.77	-24.35	0.79	* -3.39	*11.49
10	درجة التركيز السلعي للصادرات وقود معدني ومواد متصلة به	-0.03	-0.04	0.98	** -7.17	**51.47

المصدر: حسب من بيانات الجدول (3).

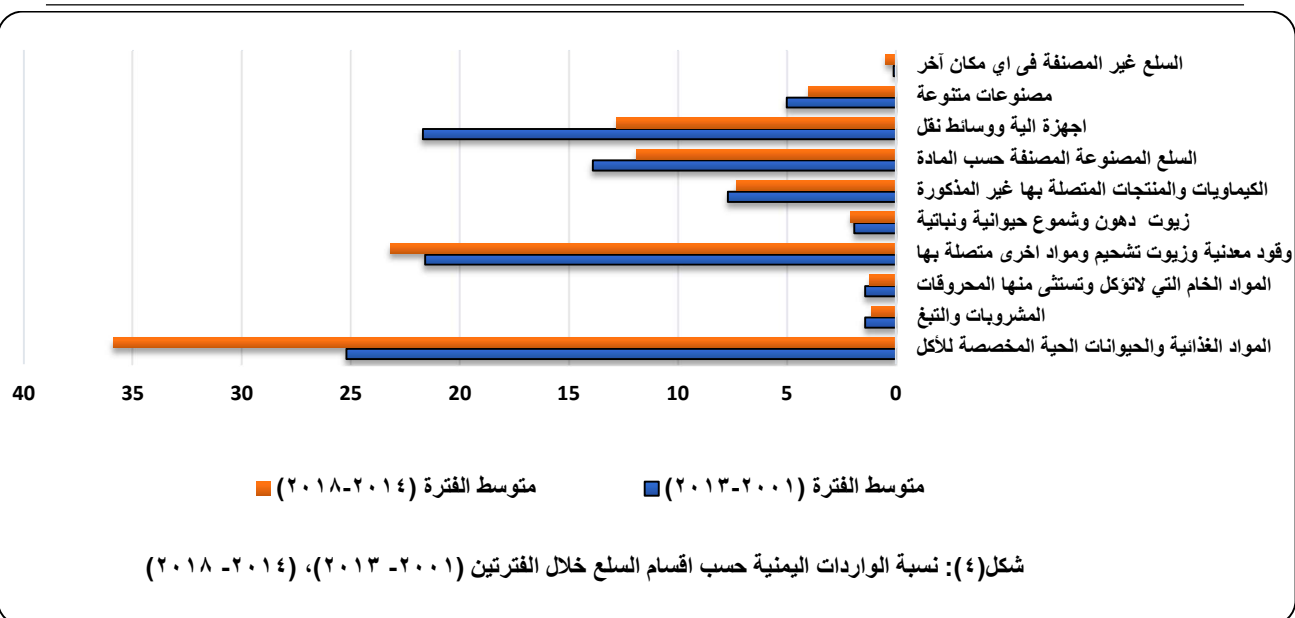
جدول (5): نسبة الصادرات اليمنية حسب اقسام السلع خلال الفترتين (2013 - 2001)، (2018 - 2014)										
السنوات	المواد الغذائية والحيوانات الحية المخصصة للأكل	المشروبات والتبغ	المواد الخام التي لا تؤكل وتستهلك منها المحروقات	وقود معدنية وزيوت تشحيم ومواد اخرى متصلة بها	دهون زيوت وشموع حيوانية ونباتية	الكيمياويات والمنتجات المتصلة بها غير المذكورة	السلع المصنوعة حسب المادة	اجهزة الية ووسائط نقل	مصنوعات متنوعة	السلع غير المصنفة في أي مكان آخر
2001	3.49	0.15	0.71	94.36	0.04	0.33	0.31	0.45	0.17	0.01
2002	4.77	0.21	0.78	90.50	0.05	0.32	0.30	2.23	0.83	0.00
2003	4.34	0.40	0.73	90.32	0.13	0.31	0.25	2.24	1.29	0.00
2004	4.38	0.36	0.51	91.17	0.12	0.85	0.38	1.74	0.49	0.00
2005	3.91	0.43	0.25	91.57	0.09	1.34	0.33	1.86	0.22	0.00
2006	3.68	0.43	0.23	91.64	0.11	0.85	0.51	2.28	0.26	0.00
2007	4.74	0.45	0.37	88.78	0.12	2.55	0.58	2.07	0.35	0.00
2008	5.02	0.28	0.22	87.25	0.10	1.67	0.45	4.53	0.49	0.00
2009	5.40	0.45	0.34	89.04	0.07	1.16	0.87	2.32	0.34	0.01
2010	6.44	0.42	0.40	87.79	0.09	1.58	0.84	2.20	0.24	0.00
2011	6.65	0.33	0.33	86.26	0.15	3.23	1.02	1.76	0.27	0.00
2012	5.99	0.22	0.24	86.95	0.15	3.26	0.92	2.07	0.19	0.00
2013	7.59	0.20	0.63	79.85	0.10	9.39	0.63	1.42	0.18	0.00
2014	6.80	0.21	0.42	78.39	0.20	7.42	1.10	5.07	0.12	0.26
2015	25.62	0.89	0.82	48.78	0.67	6.06	1.98	14.74	0.28	0.16
2016	75.09	2.18	1.38	0.31	2.17	2.03	3.61	9.26	1.69	2.27
2017	77.84	1.90	4.63	0.00	1.10	1.43	5.15	7.60	0.15	0.21
2018	97.58	0.00	1.81	0.00	0.00	0.19	0.24	0.17	0.01	0.00
متوسط الفترة -2001) (2013)	5.1	0.3	0.4	88.9	0.1	2.1	0.6	2.1	0.4	0.0
متوسط الفترة -2014) (2018)	56.6	1.0	1.8	25.5	0.8	3.4	2.4	7.4	0.4	0.6

المصدر: "كتاب الإحصاء السنوي"، الجهاز المركزي للإحصاء ووزارة التخطيط، الجمهورية اليمنية، اعداد متفرقة



جدول (6): نسبة الواردات اليمنية حسب اقسام السلع خلال الفترتين (2013-2001)، (2018-2014)										
السلع غير المصنفة في مكان اي آخر	مصنوعات متنوعة	اجهزة الية ووسائط نقل	السلع المصنوعة حسب المادة	الكيمائيات والمنتجات المتصلة بها غير المذكورة	زيوت دهون وشموع حيوانية ونباتية	وقود وزيت تشحيم ومواد اخرى	المواد الخام التي لاتؤكل وتستهنى منها المحروقات	المشروبات والتبغ	المواد الغذائية والحيوانات الحية المخصصة للاكل	السنوات
0.14	4.69	22.90	16.07	9.23	1.94	12.03	2.57	1.41	29.03	2001
0.05	5.07	26.28	15.13	8.67	1.79	14.65	2.18	1.44	24.73	2002
0.06	5.51	26.39	16.08	7.85	1.89	14.86	2.14	1.63	23.58	2003
0.16	7.23	27.42	14.98	8.40	2.02	12.08	1.46	1.56	24.69	2004
0.06	6.42	21.06	15.18	8.75	2.19	19.34	1.34	2.24	23.43	2005
0.08	5.69	22.22	16.79	7.98	1.89	21.55	1.03	1.28	21.49	2006
0.20	5.93	23.98	15.53	7.18	1.56	21.42	0.95	1.03	22.22	2007
0.37	3.68	22.45	12.35	6.41	1.42	29.05	0.89	1.04	22.34	2008
0.09	6.63	23.18	13.44	6.92	1.18	21.02	1.11	1.51	24.93	2009
0.15	3.69	20.91	13.59	7.37	3.32	23.68	1.06	1.33	24.90	2010
0.01	3.23	15.33	9.87	6.88	2.05	31.08	0.99	1.24	29.34	2011
0.06	3.74	14.47	11.02	7.62	2.25	27.06	0.86	1.39	31.55	2012
0.35	3.50	15.71	10.81	7.21	1.83	32.36	1.10	1.25	25.87	2013
0.37	4.67	17.41	14.20	7.57	2.42	21.86	1.35	1.26	28.89	2014
2.07	3.81	14.98	11.34	7.19	3.10	16.94	1.12	1.61	37.83	2015
0.01	4.20	13.01	16.49	9.32	2.53	16.34	1.17	1.23	35.68	2016
0.00	3.35	12.42	8.96	5.40	1.55	27.26	1.36	0.77	38.93	2017
0.00	4.19	6.00	8.67	6.92	1.09	33.54	0.82	0.50	38.27	2018
0.1	5.0	21.7	13.9	7.7	1.9	21.6	1.4	1.4	25.2	متوسط الفترة (2013-2001)
0.5	4.0	12.8	11.9	7.3	2.1	23.2	1.2	1.1	35.9	متوسط الفترة (2018-2014)

المصدر: "كتاب الإحصاء السنوي"، الجهاز المركزي للإحصاء وزارة التخطيط، الجمهورية اليمنية، اعداد متفرقة



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# The Impact of Yemen's Acceptance to Join the World Trade Organization on Foreign Trade Efficiency

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## ABSTRACT

Yemen's accession to the World Trade Organization was a goal for successive Yemeni governments. In order to achieve this goal, it entered into long and arduous negotiations. Yemen took about thirteen years from the date of submitting the official application for accession. It continued to work hard and make continuous national efforts to achieve this goal. In December 2013, Yemen's application was accepted to become the 160<sup>th</sup> member of the World Trade Organization. The study aimed to explore the status of Yemeni foreign trade by studying the economic indicators of the status of foreign trade and to know the impact of Yemen's acceptance of joining the organization by identifying the most important indicators of foreign trade efficiency, with a focus on studying these indicators during the two study periods, which were divided into the period before Yemen's acceptance of joining the World Trade Organization as a first period and after Yemen's acceptance of joining the organization as a second period. The study relied on the descriptive and quantitative analytical approach. The study was based on published and other secondary data collected from reports and statistics issued by government agencies. The study concluded that the second period witnessed a decrease in average exports while the average imports increased, so the trade balance deficit increased. It also showed that the average of most economic variables and study indicators in the second period decreased, with the exception of imports and GDP. It also became clear that there was an increase in the degree of concentration of exports and imports in the two study periods. It was found that Yemen did not benefit from providing some transitional periods or from any advantages that would have been provided to Yemen during the transitional period that followed the date of Yemen's acceptance as one of the least developed countries. The study recommended the necessity of national reconciliation, ending the war, and working to reconsider the policies followed in the field of foreign trade for what is in the interest of Yemen, and working with the international community to remove the effects and improve the economic and commercial situation and working with the relevant international bodies.

**Keywords:** Yemeni Foreign Trade, World Trade Organization

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**Original Article**

# Gross, histological and histochemical investigation of the stomach of the Eurasian stone curlew (*Burhinus oedicnemus*) and pied king fisher (*Ceryle rudis*)

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**KEYWORDS**

Gross,  
Microscopic,  
Histochemical  
study, stone  
curlew, Pied  
kingfisher,  
Stomach

**ABSTRACT**

The structure of the stomach is correlated to the type of the food of the organism. This study investigated the gross, microscopic, histochemical and ultrastructure of the stomach of the stone curlew and pied king fisher. Six adult stone curlew and six adult pied kingfisher of both sexes were used. The results revealed that, the proventriculus was truncated cone- shaped organ in curlew; while, it is very short tube-like in kingfisher. The mucosal surface of the proventriculus has proventricular papillae over its entire surface. The ventriculus was biconvex lens in shape in curlew; while, in kingfisher it is sac-like organ. The thick muscular wall in curlew consisted of the *Crassus caudodorsalis*, *C. cranioventralis* muscles, *tenuis craniodorsalis* and *caudoventralis*; while, the wall is thin in kingfisher so this organization is unclear. The proventriculus and ventriculus in both studied birds have folds of the tunica mucosa lined by columnar epithelium. Simple tubular glands occupied the lamina propria. The ventricular glands were lined by simple columnar cells. The proventricular glands were situated between the inner and outer layers of the lamina muscularis mucosae. The tunica submucosa was very thin in the proventricular wall; while, in the ventriculus, it was not separated from the lamina propria due to the absence of any lamina muscularis mucosae. Muscosa of ventriculus in kingfisher consisted of three layers: an internal longitudinal layer, a middle circular layer and an external layer of longitudinal smooth muscle fibers; while, in curlew the outer longitudinal layer was absent. In conclusion, the study detected many variations in the stomach structures of birds subjected to study and these differences could be due to the differences in food habit. Further studies should be carried out for more understanding the physiological process of digestion and nutrient absorption in these birds.

**Article`s history**

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**INTRODUCTION**

Egypt is located at the Northeastern corner of Africa and occupies an area of about one million kilometers. It enjoys a unique strategic location, at the crossroads between Africa, the Middle East, and Europe. Egypt is divided into four geographical regions, namely, Nile Valley and Delta, Western Desert, Eastern Desert, and

Sinai. The country is rich in wild bird species due to its wide range of habitats (Issa, 2019). The Eurasian stone-curlews, also known as dikkops or thick-knees, consist of 10 species within the family Burhinidae, and are found throughout the tropical and temperate parts of the world, with two or more species occurring in some areas of Africa, Asia, and Australia. Despite the group being



classified as waders, most species have a preference for arid or semiarid habitats Bock (1994). It is a species of European conservation concern (BLI, 2012; BLI, 2015). The Eurasian stone-curlew is largely nocturnal, especially when singing its loud wailing songs. Its food consists of insects and other small invertebrates, and occasionally small reptiles, frogs and rodents (Dunning, 1992). Eurasian Stone Curlew *Burhinus oedicnemus* is a summer breeder in Turkey (Boyla 2016), a resident breeder in Cyprus (Bird Life International, 2015).

Pied kingfisher (*Ceryle rudis*) belongs to a family of ~90 species that range in size from the 9-g African Dwarf Kingfisher (*Ceyx lecontei*) to the ~500-g Laughing Kookaburra, *Dacelo novaeguineae* (Woodall 2001), widely distributed across Africa and Asia. It was one of the three most common types in the world. In ancient times believed this type descended from an ancestral American green kingfisher which crossed the Atlantic Ocean about 1 million years ago (Fry, 1980; Al-Mamoori, 2016). The Pied Kingfisher (*Ceryle rudis*) characterized by maculata plumage consisting of the black and the white color. It's non-migratory birds, can be seen near lakes and rivers, and the feeds mainly on fish, crustaceans and large aquatic insects such as dragonfly larvae fish (Wanink, 1994; Al-Mamoori, 2016). Its characterized by ability to fly for a long time (fry et al, 1992; Dyce et al., 2010; Al-Mamoori, 2016). The digestive system in birds composed of buccal cavity, pharynx, esophagus, proventriculus, gizzard, small and large intestine and cloaca (Al Kinany, 2017). Clear variations are reported in avian digestive tract and type of food ingested (Al Kinany, 2017). The avian wall of digestive tract is composed mainly of four basis layers arranged from inner to outer, mucosa, submucosa, muscularis externa There is some variations in the microscopic structure and also thickness of these layers according to types of birds also types of ingested food (Rajabi and Nabipour, 2009).

Bird could be classified to three categories or group in relation to their stomachs function and food digestion process; first group; birds eat soft food, in this group, the gizzard acts as stock piling of food. Second group; birds eat hard diet and gizzard grinds the food and third group, birds eat intermediate diet and the gizzard acts for storage and physical digestion (Hassouna, 2001).

Due to the dearth of information on histological and anatomical structures of digestive system in wild birds, especially **Eurasian stone curlew and pied king fisher** birds. The aim of the present study was to illustrate the morphology, histology,

histochemistry, and ultrastructure of the stomach of the Eurasian stone curlew and pied kingfisher. These observations will provide a basis for understanding the digestive physiology and help pathologists and nutritionists in future studies on diet and diseases affecting the species by facilitating the histopathological diagnosis of such diseases affecting bird digestive system.

## Materials and Methods

### Study area and Experimental birds

A total of twelve adult apparently healthy birds of both sexes from **Eurasian stone curlew and pied kingfisher birds**, were obtained from bird's hunters at Sharkeia governorate, Egypt between years of 2023-2024. Species identification and age determination were adopted according to keys given by Klos and Lang (1982). The current work was completed in accordance with animal welfare guidelines and the Faculty of Veterinary Medicine, Suez Canal University Ethics Committee, as well as Egyptian laws.

### Gross morphological examination

Four birds from each species were selected, weighed, and anaesthetized with chloroform, slaughtered and allowed to exsanguinate. The ventral body wall of birds were longitudinally incised from the vent as far as the cranial end of the sternum, the flaps of the body wall were reflected on both sides sternum. The birds were laterally dissected, and the upper digestive tract were photographed in situ to provide a detailed description of its shape, position, and relationships with other organs, according the technique described by Basha et al. (2023).

### Macro-morphometric measurements

The macro-morphometric measurements were performed as the following, the upper digestive tract birds were carefully resected. The stomachs were grossly examined in situ and carefully dissected, the isolated whole stomach, glandular stomach and muscular stomach were weighed, photographed. Gross morphometric measurements were conducted using Vernier's caliber following the procedures outlined by El Nahla et al. (2011) and El Mahdy et al. (2022)

### Light microscopic examination

Small pieces of 1 cm<sup>3</sup> were taken immediately from same specimen of proventriculus and gizzard, that were used previously for the gross examination. specimens were fixed in 10% formaldehyde for one week, dehydrated at increasing ethanol concentrations, embedded in paraffin, sectioned at 5.0 μm with a rotary microtome and stained with hematoxylin–eosin (H&E), Masson's trichrome stain,

Verheofen van Gieson stain, Alcian blue (AB) and Periodic acid Schiff (PAS) stains according guidance and keys given by Bancroft et al (2008).

### Scanning electron microscopy

The remaining birds from each species (two birds each) were utilized for scanning electron microscopic examination. The specimens were placed in 2.5% glutaraldehyde for 24 h at 4°C, then washed with phosphate-buffered saline (PBS, pH 7.4). Subsequently, the specimens were post-fixed in 1% aqueous osmium tetroxide for 4 h and rinsed in PBS (pH 7.4). After then the samples were dehydrated in ascending grades of ethanol and underwent critical point drying. The dried specimens were sputtered with a layer of gold at a thickness of 100 nm using a BIO-RAD sputter apparatus (Bio-Rad) and scanned using a scanning electron microscope (SEM, Model-JEOL ASID-10, Cambridge Ltd.) in the National Research Center, Cairo, Egypt. The scanning process was carried out according to instructions of manufacturer. The histological analysis and identification of stomach ultrastructures were performed by researchers and assistance from experts in the above mentioned center.

## RESULTS

### Gross Morphological Structures

#### Glandular Stomach (proventriculus)

The result revealed that, the glandular stomach is an elongated, truncated cone-shaped organ in curlew; while, it is very short tube-like in kingfisher. It is directed craniocaudally somewhat ventrally and to the left, in the left ventral part of the body cavity. It extends between the levels of the 3<sup>rd</sup> and 7<sup>th</sup> in kingfisher, 3<sup>rd</sup> and 6<sup>th</sup> in curlew (Fig. 1C and D). Externally the junction of the glandular stomach and the esophagus is obvious in curlew; while, in kingfisher it is indistinct. Caudally, however, at the junction with the muscular stomach there is a distinct lighter colored constriction, the isthmus in kingfisher; while, it is unclear in curlew (Fig., 2A & B). The demarcation was by the appearance of the surface (the surface of oesophagus was smooth with longitudinal folds; while, that of proventriculus showed densely packed elevations which represent the proventricular glands (Fig. 2 C, D, E & F). The color line of demarcation in oesophagus was whitish; while that of proventriculus was light brown (Fig., 2E & F) in addition, The wall of proventriculus was thicker than that of the oesophagus. Much of the left and ventral surfaces of the glandular stomach is close to the liver, and especially to the left lobe in which it produces an

impression. The right side is caudo-dorsally close to the spleen; while, in kingfisher the spleen related to the left side of the junction of glandular and muscular stomach. The dorsal surface is related to the ventral surface of the lung (Figs., 1A & B). The caudal part of the dorsal surface is related to the left testicle in the male (and from the ovary and the cranial part of the oviduct in the female) (Figs., 1A & B).

Examination of the mucosal surface of the proventriculus revealed the presence of raised papillae, papillae proventricularis, over its entire surface (Fig. 1). The average number of the proventricular papillae in curlew was  $167 \pm 1.99 / \text{cm}^2$  whereas; in kingfisher was  $229 \pm 2.08 / \text{cm}^2$ . The mean length of the proventriculus in curlew was  $1.885 \pm 0.016$  cm; whereas, in kingfisher was  $1.071 \pm 0.025$  cm. The diameter of the proventriculus in curlew was  $1.935 \pm 0.027$  cm; whereas, king fisher was  $1.47 \pm 0.038$  cm. The other morphometrical measurements were illustrated in Table 1.

#### Muscular Stomach

The muscular stomach is a large organ shaped like a biconvex lens in curlew; while, in kingfisher it is sac-like organ. Its craniocaudal diameter is greater than its dorsoventral diameter. It lay in the left caudo-dorsal region of the thoraco-abdominal cavity (Figs. 1C & D) in all examined species. It is situated between approximately the levels of the 1<sup>st</sup> and 12<sup>th</sup> lumbosacral vertebrae in kingfisher and 1<sup>st</sup> and 10<sup>th</sup> lumbosacral vertebrae in the curlew. It lies essentially in the vertical plane. However, its craniocaudal axis is directed somewhat ventrally and to the right in the left ventral part of the body cavity, and its most ventral part often crosses the midline to the right side. Its right surface related to the right lobe of the liver and the descending lobe of duodenum in kingfisher the right lobe of liver covers the cranial third of the right surface of the ventriculus; while, in curlew it covers all the same surface (Figs. 1A & B). It joined the proventriculus by the cardiac sphincter and joined the hind gut by the pyloric sphincter. In the two examined species the cranial one third of the left surface is related to the left lobe of liver; while, the caudal two thirds were against the flank covered by the abdominal air sac (Figs. 1). The craniodorsal sac is ill-distinct in all examined species; while, the caudoventral blind sac is only visible in same extremity of the ventriculus of the curlew.

In the male and female, part of the jejunum also lies dorsal to the muscular stomach. The dorsal part of the right surface is separated from the intestine by the left abdominal air sac. The ventral part is close to the descending and ascending parts of the duodenum and the pancreas. Caudal to the muscular stomach are the loop of

the duodenum, part of the jejunum and the distal parts of the ceca (Figs. 1). The dark-colored smooth muscle of the muscular stomach is moderately developed and can be separated into two lateral muscles (the dorsal and ventral muscles) of the body in kingfisher; while, curlew has additional intermediate muscle (the caudoventral muscles) of the blind sac. All muscles attach to extensive aponeuroses in the right and left walls (Fig. 2A & B). Of the two lateral muscles the dorsal muscle extends between the aponeuroses and over the dorsal surface of the muscular stomach. The ventral muscle is similarly distributed over the ventral surface. The lateral muscles are circularly orientated. The thickness, however, is asymmetrical since the dorsal muscle is thicker caudally and the ventral muscle thicker cranially. The intermediate muscle in curlew extend between the aponeuroses over the blind sacs. It is thinner than the lateral muscles. The caudoventral intermediate muscle in curlew is continuous with the ventral lateral muscle. These muscles responsible to crush the food content of the ventriculus. The pyloric region of the stomach, connecting the ventriculus and duodenum arose from the right face of the ventriculus. The inner aspect of the ventriculus in all examined species was lined by a hardened membrane, the cuticula gastrica, which is light orange in king fisher; while, in curlew it is grayish (Fig. 2A & B). The color of the mucosa of Isthmus gastric was pinkish in curlew; while, it is ill-distinct in kingfisher (Fig., 2C & D). No stones or grit were found in the three species examined (Fig. 2).

The mean length of the ventriculus in curlew was  $4.28 \pm 0.049$  cm; while, in kingfisher it is about  $2.937 \pm 0.014$  cm. The mean width of the ventriculus in curlew is  $3.194 \pm 0.018$  cm; while, in kingfisher about  $2.645 \pm 0.075$  cm. The mean wall thickness of the ventriculus in curlew was  $0.879 \pm 0.031$  cm; while, in king fisher about  $0.197 \pm 0.001$  cm. The other morphometrical measurements were illustrated in Table 1.

## Histological findings

### Proventriculus

The results of histological examination showed that the wall of the proventriculus and ventriculus consisted of four layers: a mucous membrane (tunica mucosa gastris), the submucosa (tela submucosa gastris), a muscular layer (tunica muscularis gastris) and the serosa (tunica serosa gastris). The mucous membrane (tunica mucosa) presented folds (plicae proventriculares) and sulci at its luminal surface (Fig. 3) in curlew. The folds varied in height. These folds are

unclear in kingfisher. Some of the folds were confluent with each other. The folds were lined by a columnar epithelium, but the cells seemed to diminish in height, becoming cuboidal towards the base of the sulci. Sections stained by PAS showed a positive reaction in curlew for neutral mucin (PAS positive), especially in the upper part of the folds and the surface epithelia (Fig. 3); while, it gives negative reaction in kingfisher. From the base of these folds, in curlew short simple tubular glands extended through the lamina propria. The glandular cell lining was similar to that of the folds lining the epithelium. These glands in kingfisher are tubuloalveolar and too crowded in the lamina propra. The lamina muscularis mucosae consisted of an inner layer, which appeared as longitudinal smooth muscle bundles lying along the inner surface of the lobules of the proventricular glands (Fig. 3), and an external layer of longitudinally disposed smooth muscle fibers that appeared thicker, especially opposite the areas between the lobules of the glands (Fig. 3). The lamina propria showed many mucous glands with lymphatic infiltration. The proventricular glands occupied the main part of the proventricular wall. The lobules of the glands were conical or rounded in curlew and elongated oval in kingfisher and are demarcated from one another by connective tissue fibers rich in blood vessels (Figs. 3). Each glandular lobule consisted of tubulo-alveolar units. These secretory units were lined by cuboidal in curlew and kingfisher that were juxtaposed in their basal portions where they made contact only with adjacent cells, giving them a dentate appearance (Figs., 3). These cells mostly had a conical shape, with a nucleus located basally and the free surface of each cell extending into the lumen of the gland, but cells with wide straight apices and a centrally located nucleus were also seen. The collecting tubules and excretory ducts were lined by a tall, simple columnar epithelium; the glandular cells of the collecting ducts showed a dentate appearance similar to that of the glandular alveolar cells (Fig. 3). However, each glandular cell group drained into the main proventricular lumen through a single mucosal papilla. The nuclei of the cells of the proventricular glands were large, round and regular. The proventricular glandular cells showed a negative reaction with the blue-PAS technique for neutral mucins but the basal lamina showed positive reaction (Fig. 3); while, in curlew it is positive. The telasubmucosa was a narrow connective tissue layer sandwiched between the circular layer of the tunica muscularis and the main mass of the lamina muscularis mucosae (Fig. 3). The tunica muscularis consisted of an inner longitudinal, middle circular layer of smooth muscle fibres and an external longitudinal layer (Fig. 3) in the two

species, the longitudinal layer is thicker. The tunica serosa consisted of connective tissue rich in blood vessels, a nervous plexus and adipose tissue, all covered by mesothelium (squamous cell layer).

### Ventriculus

The ventriculus of the two species was characterized by an internal abrasion-resistant lining membrane (koilin) and a thick muscular tunic. The tunica mucosa was covered by an inner layer or 'horizontal koilin lining' which was a PAS-positive layer. The koilin is thick in curlew. The folds of the mucous membrane are lined by columnar epithelium in the two species (Fig. 4). In curlew, the cells at the tip of the epithelial folds appeared taller. The epithelial folds are longer in curlew. The cells at the tip of the epithelial folds appeared taller and seemed to have larger secretory vesicles in all species examined which stained green with Masson's trichrome stain, revealing their mucous secretions; they secrete mucous which appeared mostly in the lumen and underneath the koilin lining (Fig. 4).

Simple tubular glands extended from the lamina propria to the surface epithelium. Each tubule consisted chiefly of cuboidal cells with large, round nuclei in a basophilic cytoplasm and a few, large, pale staining basal cells (Fig. 4). The glandular lumina were filled with PAS-positive vertical koilin material (basal and luminal secretions) that extended to the horizontal koilin lining (Fig. 4).

The basal ends of the glands, which were situated deeply in the lamina propria, showed great coiling (Fig., 4). The lamina muscularis mucosae consists of thick layer of longitudinally arranged smooth muscle cells (Fig. 4). The ventricular glands obscured most of the lamina propria, terminating at a layer of dense connective tissue known as the tela submucosa (Fig. 4). The tunica muscularis in kingfisher consisted of three layers: an internal longitudinal layer, a middle circular layer and an external layer of longitudinal smooth muscle fibres; while, in curlew the outer longitudinal layer was absent. The circular layer forms most of the bulk of tunica muscularis in the two species. The muscle bundles were extensively surrounded by dense connective tissue fibres (Fig. 4). The tunica serosa consisted of connective tissue and ganglionic cells of the nervous plexus that were covered by mesothelium (Fig. 4).

### Scanning microscopic findings

The epithelium and lamina muscularis mucosa of proventriculus are thicker in curlew than kingfisher (Fig. 5). The surface of the mucosa of gizzard was even in curlew; while, in kingfisher it was folded (Fig. 6). The opening of the tubular glands of gizzard were wide, circular with the same size and regularly distributed filled with vertical koilin in curlew; while, in kingfisher they were very small irregularly distributed with different sizes (Fig. 6). The tubular glands of gizzard are more numerous in kingfisher than curlew, while the epithelium and tunica muscularis is thicker in curlew than kingfisher (Fig. 6).

**Table 1. Gross morphometrically measurements of the stomach in Stone curlew and pied kingfisher**

Stomach's part	Measurement	Stone curlew	Pied kingfisher
General	Whole weight of bird (gm)	387.5 ± 2.82	95 ± 1.8
	Whole GIT length (cm)	89.438 ± 0.049	91.50 ± 0.01
	Weight of whole stomach (gm)	11.68 ± 0.163	2.85 ± 0.07
	Weight ratio of whole stomach to body weight	3%	3%
	Length ratio/ GIT	12.90%	7.80%
Proventriculus	Wall thickness (cm)	0.26 ± 0.017	0.06 ± 0.002
	Width (cm)	1.935 ± 0.027	1.47 ± 0.03
	Length(cm)	1.885 ± 0.016	1.071 ± 0.02
	Length ratio /GIT	2.11%	1.17%
	Weight ratio to whole stomach	11.95%	16.10%
	Wall thickness (cm)	0.344 ± 0.026	0.102 ± 0.005
	Number of proventricular gland openings /cm <sup>2</sup>	167 ± 1.99	229 ± 2.08
	Shape of the glandular opening	Rounded	Rounded
	diameter of the glandular opening (cm)	0.031 ± 0.003	0.04 ± 0.002
Ventriculus	Width (cm)	3.194 ± 0.018	2.645 ± 0.07
	Length (cm)	4.284 ± 0.049	2.937 ± 0.01
	Length ratio /GIT	4.79%	3.21%
	Weight (gm)	10.168 ± 0.014	2.348 ± 0.02
	Weight ratio to whole stomach	87.05%	82.18%
	Wall thickness (cm)	0.879 ± 0.031	0.197 ± 0.001

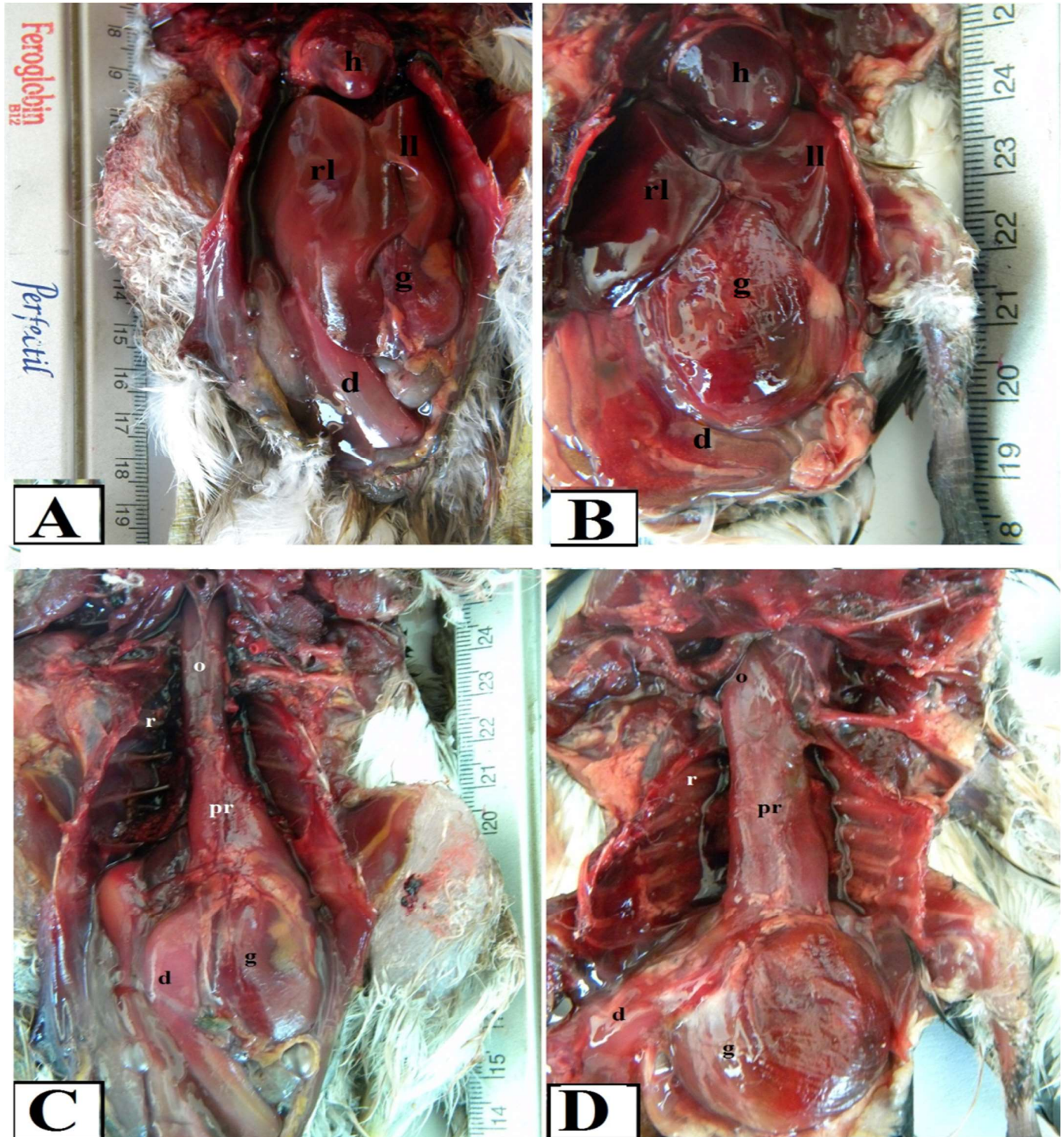


Fig.1. A photograph of ventral view of dissected thoraco-abdominal of adult curlew (A) and kingfisher (B) and after removal of liver, lung and heart of adult curlew (C) and kingfisher (D) showing, esophagus (o), heart (h), Proventriculus (pr), Ventriculus (g), right lobe of the liver (rl), left lobe of the liver (ll), duodenum (d), ribs (r).

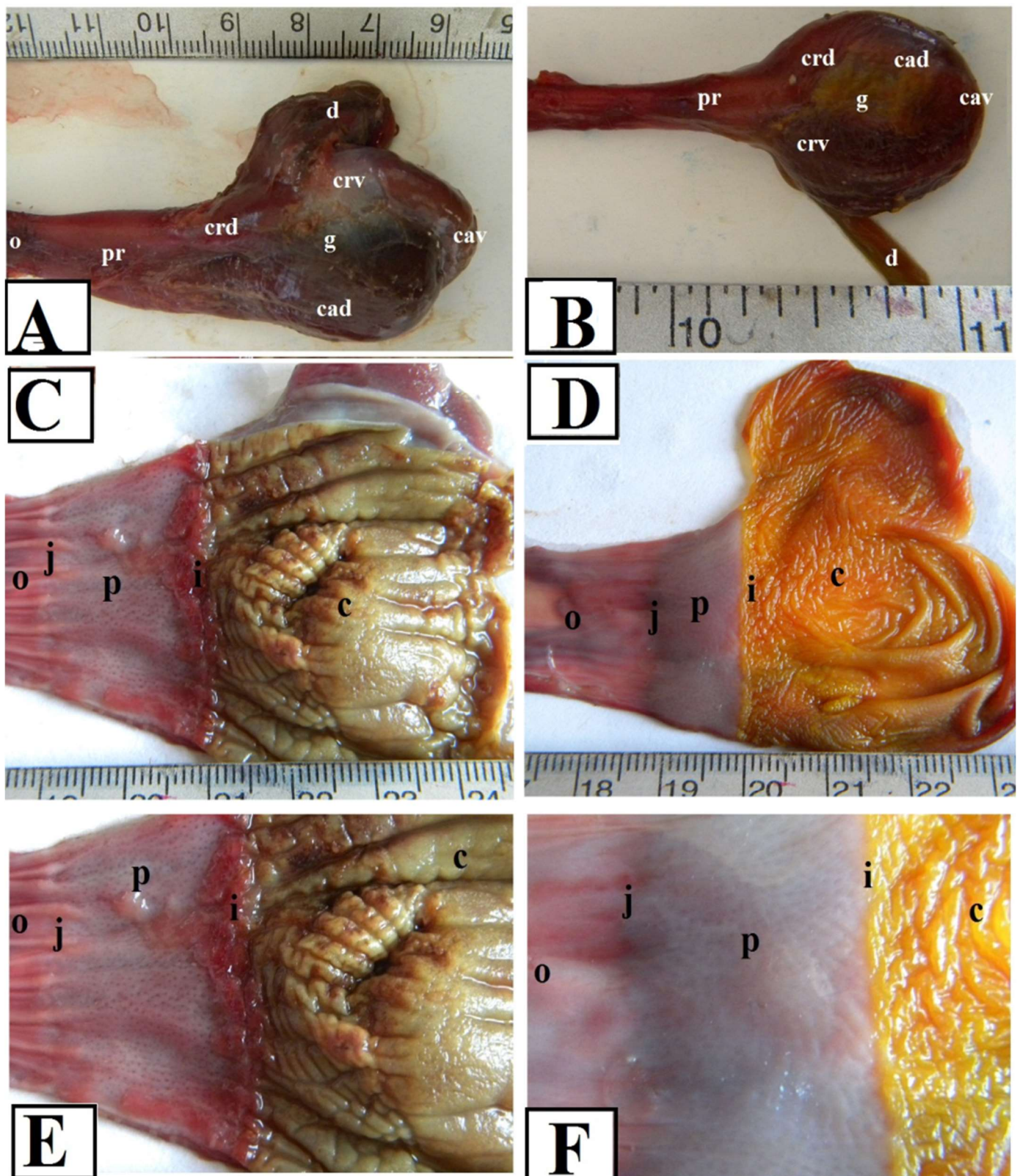


Fig.2. A photograph of intact stomach of adult curlew (A) and kingfisher (B). A photograph of the interior of the stomach of adult curlew (C&E) and kingfisher (D&F) showing, Esophagus (o), Proventriculus (pr), Ventriculus (g), *M. crassus cranioventralis* (crv), *M. tenuis craniodorsalis* (crd), *M. crassus caudodorsalis* (cad), *M. tenuis caudoventralis* (cav), isthmus gastris (i), *Junctura esophago-proventricularis* (j).

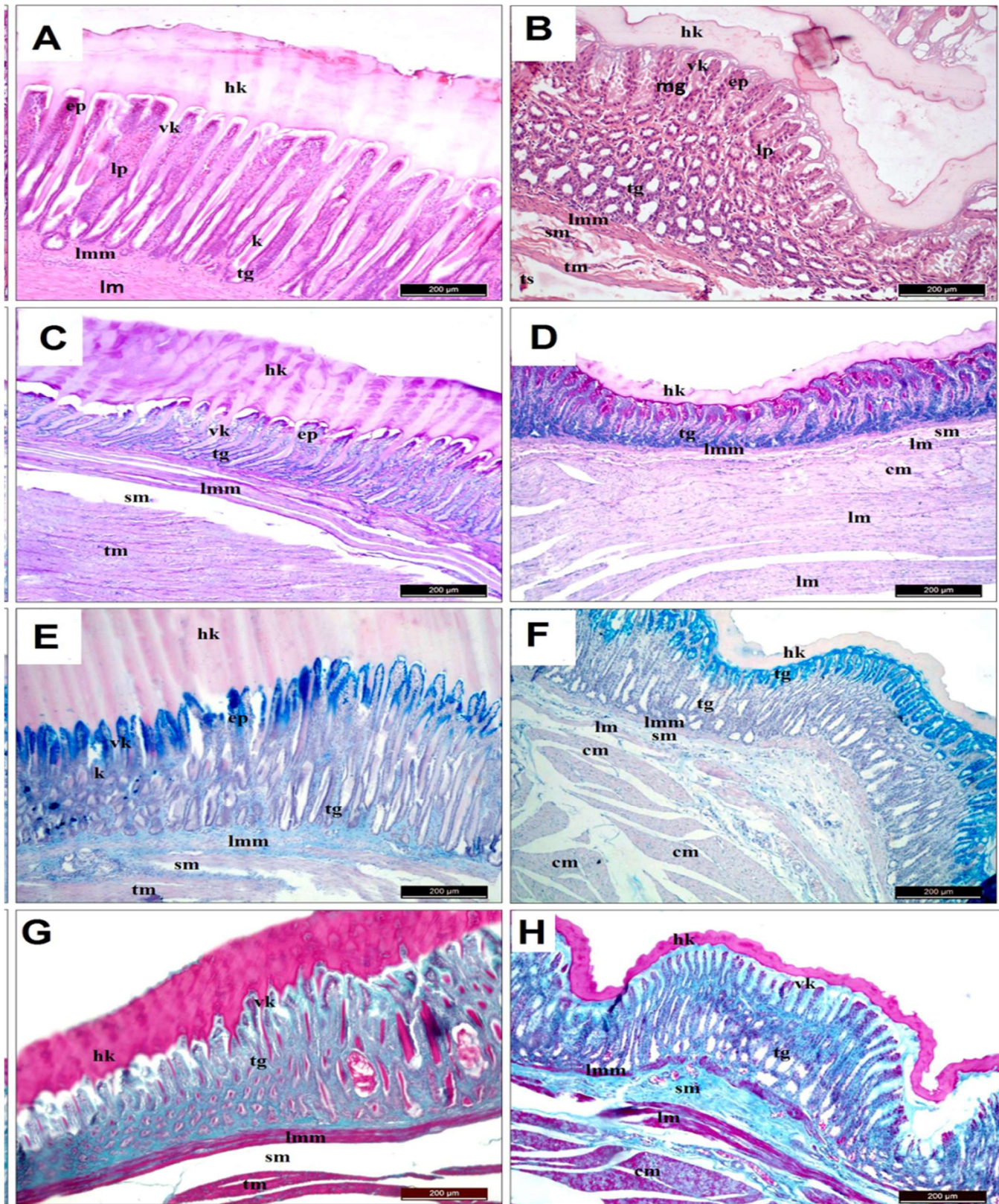


Fig. 3. A photomicrograph of a longitudinal section in the proventricular wall of adult curlew (A) and kingfisher (B) H and E, adult curlew (C) and kingfisher (D) PAS, adult curlew (E) and kingfisher (F) alcian blue and adult curlew (G) and kingfisher (H) massons trichrome showing, lamina epithelialis (ep), Lamina propria submucosa (lp), superficial proventricular simple tubular glands (tg), deep proventricular glands (pg), which had clear lumen (lg).

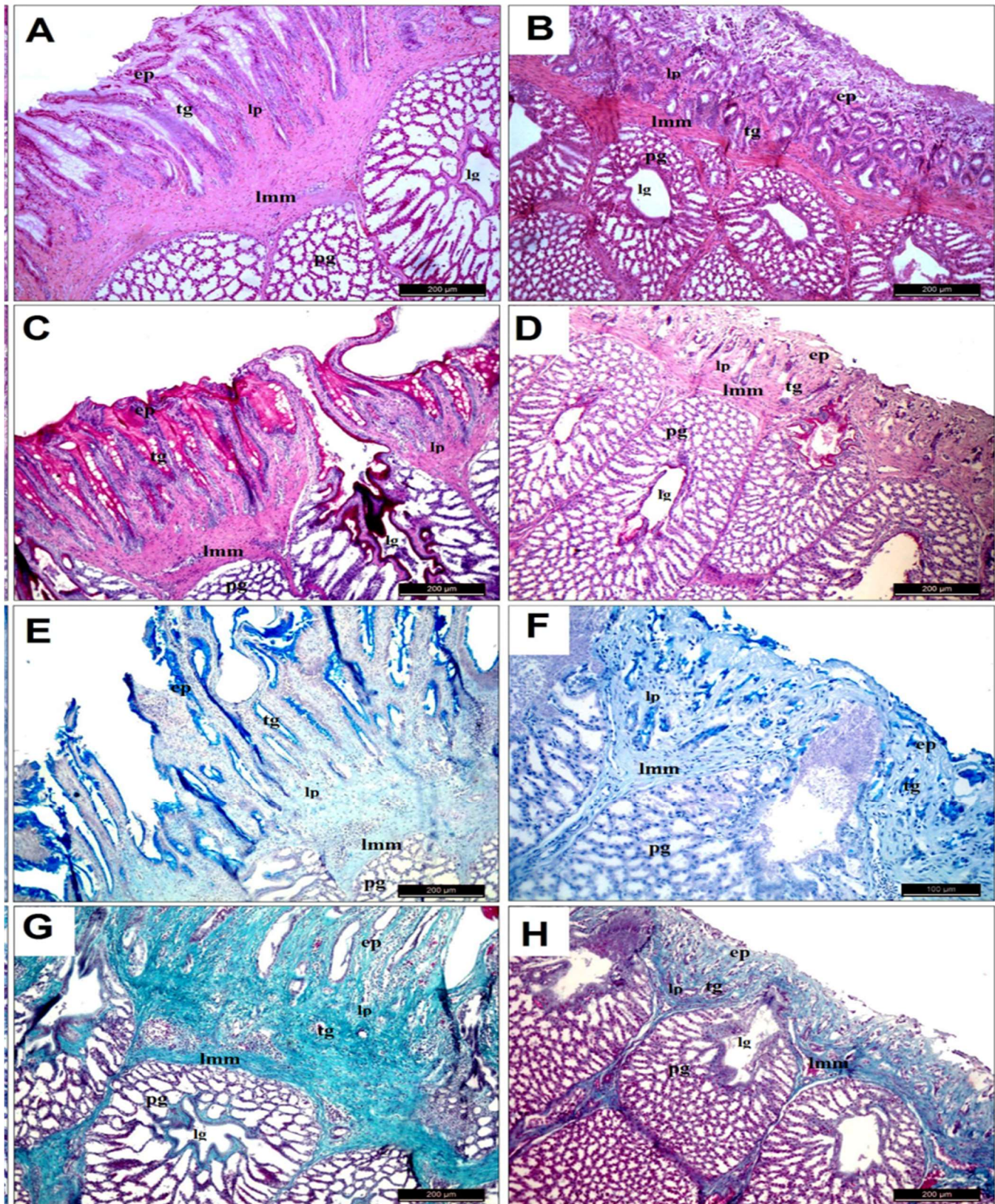


Fig. 4. A photomicrograph of a longitudinal section in the ventricular wall of adult curlew (A) and kingfisher (B) H and E, adult curlew (C) and kingfisher (D) PAS, adult curlew (E) and kingfisher (F) alcian blue and adult curlew (G) and kingfisher (H) massons trichrome showing, lamina epithelialis (ep), lamina muscularis mucosa (lmm), Lamina propria (lp), tubular glands (tg), muscular longitudinal layer (cm), smooth muscular circular layer (cm), submucosa (sm), horizontal koilin (hk), vertical koilin (vk), mucosal glands (mg).



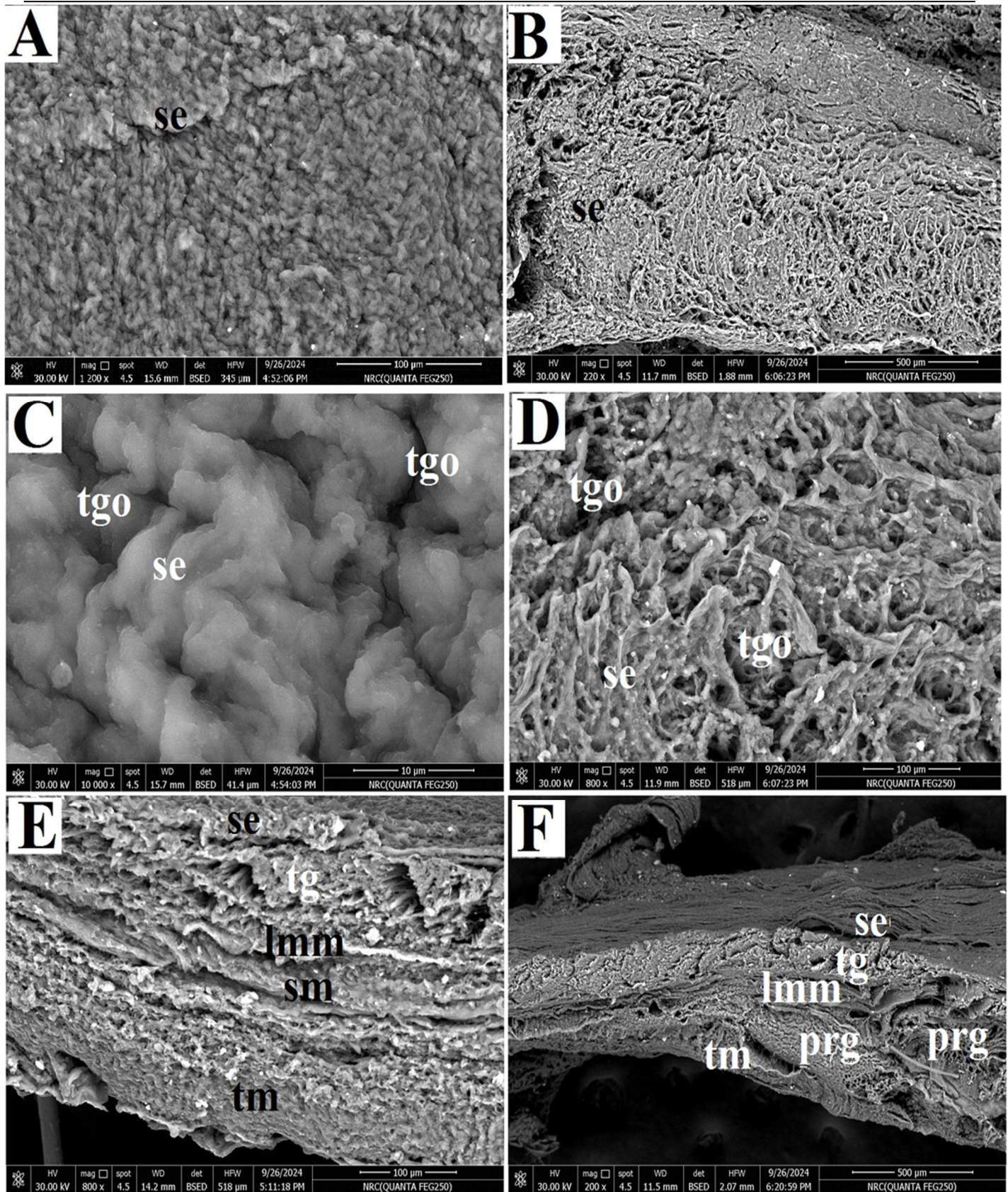


Fig.5. Scanning electron micrograph of the proventriculus of adult curlew (A) and kingfisher (B) showing, surface epithelium (se), openings of the tubular glands (tgo), tubular glands (tg), lamina muscularis mucosa (lmm), submucosa (sm), tunica muscularis (tm).

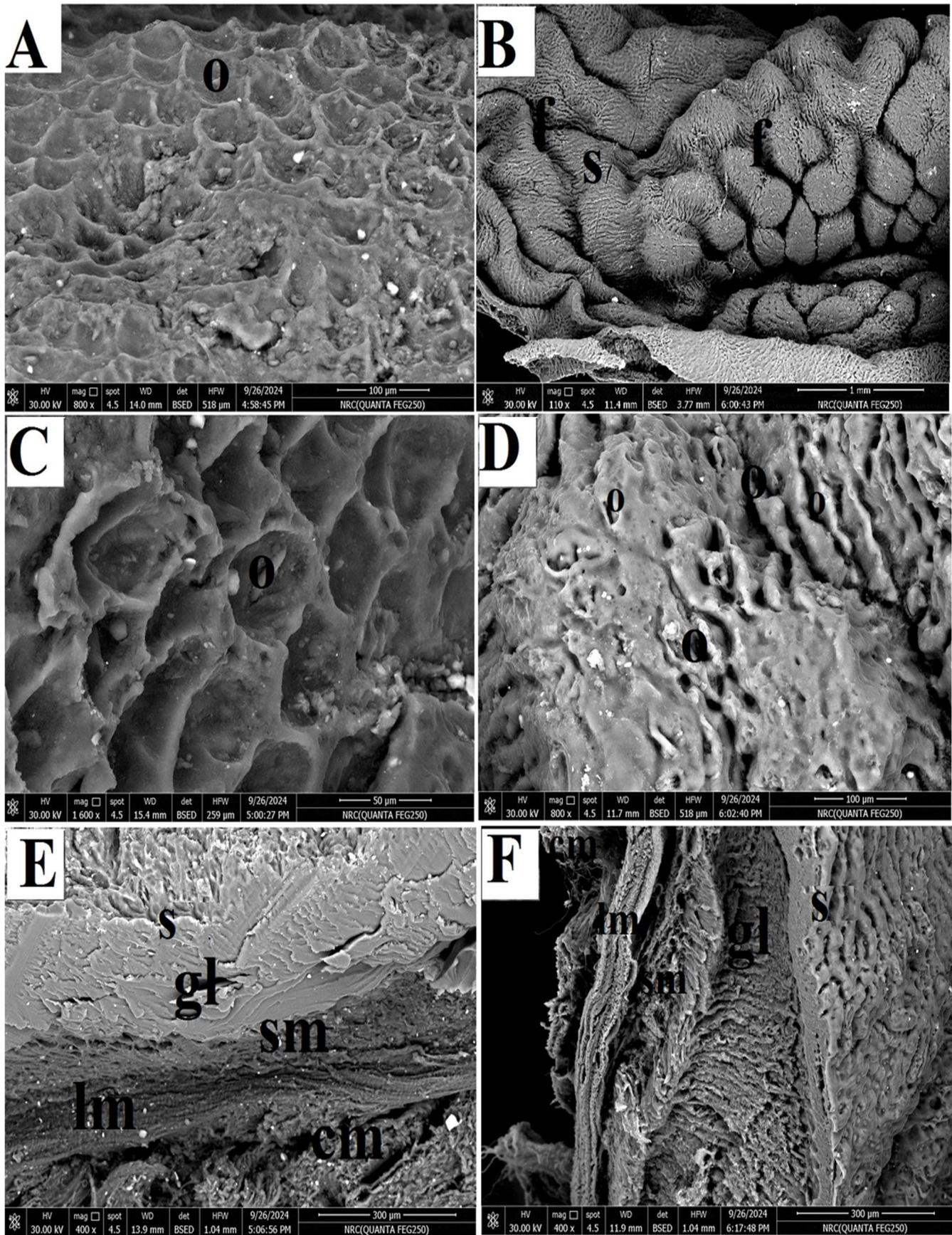


Fig.6. Scanning electron micrograph of the ventriculus of adult curlew (A) and kingfisher (B) showing, surface epithelium (s), fissure (f), openings of the tubular glands (o), tubular glands (gl), submucosa (sm), longitudinal muscular layer (lm), cercular muscular layer (cm).

## DISCUSSION

The present work was carried out on 10 birds of two species, namely, Eurasian stone curlew and pied kingfisher in order to observe the morphological and histological as well as fine structure of stomach.

The stomach of the birds is divided into two chambers. The first stomach is proventriculus and the second chamber is called gizzard or ventriculus. Gizzard stomach is grinding function of grains by their muscles, so that it's facilities indigestive process (Rebecca, 2021). The two chambers of stomach are different in size and shape depending on the nature of birds' diets as carnivores, piscivorous and granivorous birds. The glandular stomach (proventriculus) is characterized thin layer based on the food force, grains (AL-Taai, 2022). The stomach in fowl is composed of glandular stomach (proventriculus) and muscular portion that is ventriculus or gizzard (Suganuma et al., 1981; Macari et al. (1994); Dyce et al., 1996; Baily et al., 1997; Bacha and Bacha, 2000), which are separated by an isthmus. The chicken stomach is located at the left of the median line and is situated dorsal to the liver. In carnivorous and piscivorous fowls that swallow big victuals very little distinction exists between the glandular and the muscular stomach (Sisson & Grossman, 1986; Baumel et al., 1993). The statements and findings of above workers are in line with results of this study. The results displayed that, the isthmus was ill-distinct in the studied birds of this study, this could be explained that the investigated birds are carnivorous in contrary with the grainivorous species the isthmus is clear as they eat small grains like chicken (Macari et al., 1994) and bustards (Baily et al., 1997).

Macari et al. (1994; AL-Taai, 2022), cited that, the avian proventriculus is a structure located between the lower esophagus and the ventriculus, lined by a glandular mucosa with secretory function, this statement is in accordance with results of current study. The long proventriculus in curlew and king fisher may due to the need of coarse food storage like what mentioned in ratites (Angel et al. 1996); while, the very short proventriculus in bee eater, this may due to that bees do not need much digestive enzymes to be digested (Basha et al., 2023). On the inner surface of the proventriculus of the bee eater (Basha et al., 2023), chicken (Sisson & Grossman, 1986, Banks, 1992, Melvin and Reece, 1996; Turk, 1982; Dyce et al., 1996) and bustards (Baily et al., 1997), there is papillae, low and wide, on the lumen; on the apex of each papilla opens one of the proventricular glands. However, in the curlew and king fisher proventriculus there are no

grossly detected papillae, the ducts of the proventricular glands open in depressions on the mucosal surface. These findings are in agreement with results of the current study.

The mucosa is excessively folded, forming flat folds, Hassan and Moussa (2012) stated that the mucosal epithelium of the proventriculus of pigeon and duck was columnar and this is unlike the findings of Banks (1992) in fowl and Juliana et al. (2005) in partridge who stated that it is cuboidal. Banks (1992) in fowl and Hassan and Moussa (2012) in pigeon and duck and Basha et al. (2023) in bee eater observed that the lamina propria in the proventriculus is typical and it contains numerous lymphatic tissues, which are nodular or diffuse. An interrupted layer of guided fibers forms the muscularis mucosae longitudinally, and bunches are interdigitated between the mucous glands. Submucosa occupied by numerous submucosal glands, which are compound, ramified or tubular. Juliana et al. (2005) in partridge the gland lobules separated by connective tissue septa. These findings were on line with this study in curlew and king fisher.

In fowl, Banks (1992) and bee eater (Basha et al., 2023) recorded that tunica muscularis is formed of inner longitudinal, middle circular and outer longitudinal layers. Similar findings were recorded in this study; while, Juliana et al. (2005) in partridge and Hassan and Moussa (2012) in pigeon and duck stated that it is formed of inner longitudinal musculature and an outer circular layer. The tunica serosa in fowl (Banks, 1992), partridge (Juliana et al. 2005) and pigeon (Hassan and Moussa, 2012) is composed of connective tissue and a cuboidal cells layer; while, in the current study the cell layer was squamous as that recorded in duck (Hassan and Moussa, 2012). The differenced may be attributed to species and biological variation of the birds.

Ventriculus contains the acids and enzymes secreted in the gastric proventriculus (Turk, 1982; Macari et al., 1994). These findings in consistent with our results in curlew. considering the studied birds are carnivores, the reason behind that could be explained in view of Moawad et al., 2017, who stated that, the feeding activities of fishes and birds are classified according to the nature of food consumed by all fish and bird species into three categories; herbivores that eat plant material, omnivores which consume both plant and animal materials and carnivores one which consume animal material secreting acid and enzymes to digest their food.

Nickel et al. (1977) in avian, Juliana et al. 2005 in partridge as well as Baily et al. (1997) in bustards and Basha et al, in bee eater have described muscular stomach had format of a biconvex lens lying in the left dorsal and ventral regions of the thoracoabdominal cavity. Like that recorded by Chikilian and Speroni (1996) in *Nothura maculosa* and *Nothoprocta cinerascens*, the gizzard in kingfisher has round format; while, in *Crypturellus tataupa* it presents an oval format. The findings of above workers are partially in agreements with findings of current study. the contrast could be attributed to capacity factor and nature of food.

Baily et al. (1997) reported in chicken that, the ventriculus is constituted by four muscles, two thick and dark colored, the caudodorsalis and the cranioventralis; and two with fine thickness and clear colored, the craniodorsalis and the caudoventralis, that are responsible to crush the victuals ingested, These muscles are organized is ill-distinct in ours study as the species of the study are carnivores eating fish , whereas the fish are not so hard compared to grains which need high force for grinding.

Similar to our findings in curlew, Sisson and Grossman (1986) in chicken; Baily et al., (1997) in bustards and Hassan and Moussa (2012) in duck and pigeon indicated that the body of ventriculus separates the two tapering ends, the saccus cranialis and saccus caudalis; while, these two sacs are indistinct in kingfisher this may be due to that the muscular wall of the gizzard is ill-developed as they do not need much force to grind the fish.

In our study, the Ventriculus` weight recorded was 2.6% in curlew and 2.5% in king fisher body weight, these results are higher than findings reported in Houbara and Kori Bustards birds (1.3%), in chickens (1.9%), in duck (2.2%) of body weight (Hassan and Moussa, 2012), and lower than mean value reported by Basha et al. (2023) in bee eater (4.7%.) body weight. The discrepancies between our results and above findings could be attributed to the function of stomach in differs birds. Regarding the presence of stone in Ventriculus, Hassan and Moussa (2012) reported that presence of stones in ventriculi of duck and pigeon with different sizes. Moreover, they suggested that, the presence of stones probably ingested intentionally to assist with the grinding down of food; in contrast, the current study no stones were found in gizzards of all birds investigated, this could be explained that, investigated birds are carnivores and their food are fishes which needs only acid and enzymes to be digested.

Zhu, (2015) cited that, the ventriculus is internally lined by columnar epithelium has tubular glands open in crypts of the epithelium. Similarly, the inner layer of the muscular stomach of the birds subjected to investigation in this study, was lined by a thick cuticula gastrica, which is grayish in curlew and orange in kingfisher. Furthermore, the results revealed that, the cuticle is yellowish in most birds examined, this results are on parallel with findings recorded by Sukanuma et al. (1981) in wild fowls and Juliana et al. 2005 in partridge, and Baily et al. (1997) in bustards.

Basha et al. (2023) stated that, in bee eater the luminal surface of ventriculus is lined by a proteinaceous substance similar to keratin produced by mucous glands. These findings were similar to ours study findings in the two bird's species studied. George et al. (1998) claimed that the glands produce the material of the hardened membrane of the gizzard are called koilin. Furthermore, Eglitis and Knouff (1962) demonstrated that the secretion of the tubular glands was a carbohydrate-protein complex; this established the non-keratin nature of the membrane, since a carbohydrate component is absent in pure keratin. George et al. (1998) in chicken recorded that there was a layer of elastic and collagen fibers is observed surrounding the ventricular mucosae, constituting the compact stratum, and externally is limited with the submucosa. The differences in nature of material produces by above glands could be attributed to needs of digestion process and protection the wall of stomach in various birds.

In accordance to the current study, Bennett & Cobb (1969) in their studies on birds demonstrated that the muscular stomach smooth muscle is mainly disposed in crossed bunches or layers, separated by connective tissue, in relation to the other visceral muscles. Banks (1992) in chicken, Basha et al. (2023) in bee eater researched to similar results on their studies, that the serosa outer to the tunica muscularis, composed of connective tissue lined by a squamous cell layer.

## CONCLUSION

It could be concluded from this study, there are some variations between the stomach of stone-curlew and kingfisher. The stomach features undoubtedly correlated with its feeding habits. Further studies should be carried out for more understanding the behavior, digestion process and nutrient absorption of these birds.

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**AUTHORS' CONTRIBUTION**

Aref AM conducted the field survey under the supervision of Basha AAB, Aref AM and Basha AAB designed the study, prepared the primary draft; revised the manuscript; Ahmed, M.A. and Hassan, S.A. helped in processing of the specimen. All authors have seen and approved this version of the manuscript.

**CONFLICTS OF INTEREST**

No conflicts of interest have been declared.

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None

**ETHICS APPROVAL**

The study was approved by scientific research ethics committee, Faculty of Veterinary Medicine, Suez Canal University, Ismailia, Egypt.

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## دراسة عيانية ونسجية وكيميائية نسيجية لمعدة الكروان الحجري الأوراسي وصيد السمك

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### الملخص

يرتبط تركيب المعدة دائما بنوع الطعام الذي يتناوله الكائن الحي. أجريت هذه الدراسة لمعرفة البنية التشريحية والمجهرية والنسجية الكيميائية لمعدة الكروان الحجري وصيد السمك. تم استخدام ستة طيور بالغة من كروان حجري وستة طيور من صائد السمك من كلا الجنسين. كشفت النتائج ان المعدة الغدية عضوًا مخروطيًا مبتورًا في الكروان بينما كان يشبه الأنبوب قصيرًا جدًا في صائد السمك. يحتوي السطح المخاطي للمعدة الغدية على حليمات بطينية على كامل سطحه بكثافة متغيرة بين الأنواع المدروسة. كانت المعدة العضلية على شكل عدسة محدبة الشكل في الكروان بينما في طائر صائد السمك تشبه الكيس. يتم ربط المعدة العضلية بالمرىء عن طريق العضلة العاصرة الفؤادية وترتبط بالاثني عشر عن طريق العضلة العاصرة البوابية. يتكون الجدار العضلي السميك في الكروان من عضلات الخلفية العليا والامامية السفلى والامامية العليا والخلفية السفلى بينما يكون الجدار رقيقًا في صائد السمك لذا فإن هذا التقسيم العضلي غير واضح. كان السطح الداخلي للمعدة العضلية في كلا الطائرين مبطّنًا بغشاء متصلب يُسمى بشرة المعدة. اما في الدراسة لنسجية، تم صيغ عينات من المعدة الغدية والمعدة العضلية باستخدام صبغة E&H وحمض شيفف الدوري (PAS) وصبغة ماسون ثلاثية الألوان وصبغة فان جيزون. أظهرت النتائج ان المعدة الغدية والمعدة العضلية في كلا الطيور التي تمت دراستها تحتوي على طيات من الغلالة المخاطية المبطنة بظهارة عمودية. كانت الغدد البطينية مبطنة بخلايا عمودية بسيطة. تقع غد المعدة العضلية بين الطبقات الداخلية والخارجية للصفحة العضلية المخاطية. كانت الغلالة تحت المخاطية رقيقة جدًا في جدار المعدة الغدية بينما في المعدة العضلية لم يتم فصلها عن الصفحة المخصوصة بسبب عدم وجود أي صفحة عضلية مخاطية. تتكون الغلالة العضلية للمعدة الغدية من طبقة داخلية سميكة من ألياف عضلية ملساء دائرية وطبقة خارجية رقيقة من ألياف عضلية طويلة. تتكون عضلات المعدة العضلية في صائد السمك من ثلاث طبقات: طبقة طولية داخلية وطبقة دائرية متوسطة وطبقة خارجية من ألياف عضلات ملساء الطولية بينما في الكروان تكون الطبقة الطولية الخارجية غائبة. خلصت الدراسة الى ان هناك العديد من الاختلافات في تركيب المعدة للطيور التي خاضعة للدراسة ويمكن أن تكون هذه الاختلافات بسبب الاختلافات في طريقة تناول الغذاء ونوعه. توصى الدراسة بإجراء المزيد من الدراسات لفهم العملية الفسيولوجية للهضم وامتصاص العناصر الغذائية في هذه الطيور.

الكلمات المفتاحية: الكروان الحجري الأوراسي ، دراسة عيانية ونسجية وكيميائية، صياد السمك

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