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Original Article

Gastrointestinal Parasites of Local Breeds Chicken in Dhamar City

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KEYWORDS

Chicken,
Gastrointestinal
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ABSTRACT

The study was conducted with aim to determine the gastrointestinal parasites of local breed chickens (*Gallus gallus domestica*) slaughtered in Chicken`s Market at Dhamar city localities. A total of 246 faecal samples from the gastro-intestinal tracts of slaughtered chicken were collected and examined from January to June, 2023, using direct smear and sodium chloride floatation methods for the presence eggs and oocyst of gastrointestinal tract (GIT) parasites. The results demonstrated that, out of 246 samples examined, 170 (69.11%) were found positive with one or more parasites species. High infection rate was found among males (45.53%) compared to females (23.58%). The parasites species identified were *Ascaridia galli* (21.95%), *Raillietina echinobothrida* (10.57%), *Eimeria spp.* (14.63%), *Raillietina cesticillus* (9.76%), *Capillaria spp* (6.10%) and mixed infection (6.10%). Significant differences ($P<0.05$) were observed among prevalence rates of parasites identified. The distribution of parasites infections on the basis of risk factors/Characteristics, the higher rate was found in age groups of less than 5 months (30.89%), in *Albaladi Aljabali* breed (35.37%), in the month of March (17.07%) and in Anis localities (16.67); whereas, the lower infection rate was found in age group of up to 12 months (17.89%), in hybrid breeds (4.07%), in months of June (7.72%) and in Myfaa localities (10.98%). Significant differences ($P<0.05$) were observed between prevalence rate and sex, month variation (season) and area (localities); while, none with other factors. The results of the logistic regression analyses showed significant association between GIT parasites infection rate and sex (OR= .377; 95%CI: 0.216-0.656; $P= .001$), Breeds (OR= 1.366; 95%CI: 0.216-0.656; $P= 0.024$) and parasites species (OR= 0.058; 95%CI 0.026-0.130; $P= 0.000$), and none with other characteristics or risk factors investigated. In conclusion, gastrointestinal parasites infections are prevalent among local chickens in study areas. An epidemiological control programme should be put in place to minimize parasite infections and their impact on local chicken production.

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INTRODUCTION

The poultry industry occupies an important position in the provision of animal protein (meat and egg) to man and also plays an important role in the national economy as a source of revenue (FAO, 2006). Native chickens, known as *Albaladi*, are the chicken breeding commonly rearing by people traditionally under free-range or backyard control system (Zalizar (et al., 2021) but constrained by many extrinsic factors like malnutrition, poor management and the

absence of biological security which is very outstanding. In addition, predation by other animals also is effective threat to local chicken (Saidu et al., 1994; Derby and Mebrate, 2020). The chickens are generally raised in a free-range system, scavenging around the compound of households, feeding on the locally available resources like earthworm, household refuse, insects, residue from harvest, animal and human faeces etc. (Ajala et al., 2007).

Gastrointestinal tract(GIT)parasites are considered an important problem of chicken reared in rural scavenging system and incriminated as a major cause of ill-health and loss of productivity in poultry in different parts of world (Fakae and Paul-Abiade, 2003; Ajala et al., 2007).

Nematodes, Cestodes and trematodes and protozoa are important parasites of poultry production. These parasites can be found in the intestine or fecal dropping especially when expelled as fresh specimen (Fakae and Paul-Abiade, 2003; Biu and Haddabi, 2005). These parasites are found more frequently in the warm seasons, when the intermediate hosts are abundant. Beetles and houseflies inhabiting poultry houses act as intermediate host for most species of cestodes (Baba and Oveka, 2004).

Although the prevalence of parasitic infection has been greatly reduced in the commercial production system, mostly due to improve housing, hygiene and management operations (Yoriyo et al., 2008). A large number gastrointestinal parasites are still widely distributed throughout the world in free – range chicken. Previous studies (Saidu et al. (1994) ; Ruff (1999; Yoriyo et al., 2008) reported that, 35-100% of the rural scavenging chicken examined were positive for one or more of gastrointestinal parasites.

To our best knowledge, there is no literature in combined data on prevalence of gastrointestinal parasites in Yemeni local breed at Dhamar, Yemen; therefore, this study was designed to determine the gastrointestinal parasite in local chicken breed in Dhamar city, and associated risk factors.

MATERIALS AND METHODS

Study Area

A cross-sectional study was conducted between the periods of January to June 2023 in Dhamar city, Dhamar governorate. The Dhamar governorate located to the south east of Sana'a governorate, to the north of Ibb governorate, to the east of Al Hudaydah governorate and to the north west of Al Bayda'a governorate in the central highlands of Yemen. The topography of Dhamar area varies from level plain to slopes at elevation between 2400 to 2700 meters above sea level. It`s irrigated by rainfall and underground water. According to the last Census in 2004, the total population for the governorate is about 1,330,108 which expected to be 3,311,033 in 2034. Agriculture is the main economic activity in the area. Majority of population working in Agriculture (Abbas *et al.*, 2018; Al-Aizari et al., 2018).

Sample size

Since the prevalence of major GIT parasites of local chicken in Dhamar city small scale production system has not been reported, 15% expected prevalence rate was suggested with 95% confidence interval (CI) and 5% desired absolute precision following keys given by Thrusfield (2006). Therefore, the total sample was calculated using Thrusfield formula. $N = (1.96)^2 Pexp(1-Pexp)/d^2$.

Where, n = required sample size, $Pexp$ = expected prevalence and d = desired absolute precision.

Accordingly, the required sample is 246 chicken.

Collection of Samples

A total of two hundred forty-six gastrointestinal tracts of local breed chickens slaughtered in different areas of Dhamar city were collected, labeled with necessary information, and then transferred to the Department of parasitology laboratory, Tamar University for processing and examination (Afia et al., 2019).

Samples analysis

In laboratory, the gastrointestinal tract parts were separated and their contents emptied into their respectively labeled beakers. The contents were washed into a petri dish and examined under a microscope for eggs/cyst of gastrointestinal parasites qualitatively using direct wet and flotation techniques. The gastrointestinal worms were recovered as described by Hansen and Perry (1994) and Urquhart et al. (1996). The recovered worms were preserved in bottles containing 10 % formal-saline solution. The recovered worms were identified under light microscope by observation of their distinctive morphological features as described by Soulsby (1982) and Ashenafi and Eshetu (2004).

Statistical Analysis

Data Obtained from this study were summarized using Tables and histogram. Descriptive and other statistical analyses were performed by using SPSS version 21 for Windows. (Version 21; SPSS Inc., Chicago, IL, USA). Chi square, logistic regression and Pearson`s correlation analyses were used to examine the relationship between prevalence and characteristics/risk factors. The association is considered significant when p - value is less than 0.05 and insignificant when greater than 0.05.

Ethical Consideration

This research was approved by the Faculty of Agriculture and Veterinary medicine Authority,

Thamar University, Dhamar, before the commencement of the study.

RESULTS AND DISCUSSION

Disease is among the major constraint of poultry production industry (Hunduma et al., 2010). The common internal parasitic infections occur in poultry include gastrointestinal helminths (cestodes, nematodes) and protozoal parasites such as *Eimeria* species) that cause considerable damages and great economic losses to the poultry industry in the term of malnutrition, decreased feed conversion ratio, weight loss, lowered egg production and death particularly in young birds (Puttalakshamma, 2008). Furthermore, parasites can make the flock less resistant to diseases and exacerbate existing disease conditions (Gary and Richard, 2012; Katoch et al., 2012; Belete, 2016). This study aimed to determine the prevalence rate and associated risk factors of gastrointestinal parasites in free-range local chicken in Dhamar, Yemen.

The prevalence rate of gastrointestinal parasitic infection among local chickens selected and examined between January and June, 2023 in Dhamar is presented in Table 1. The results showed that out of 246 chickens examined, 170 were found infected with one or more parasite species with overall prevalence of 69.11%. These results are in agreement with findings of Asumang et al., (2019) and lower than rate reported by Negbenebor and Ali (2018) and Afia et al. (2019) in Nigeria, and higher than rate reported by Jegede et al. (2016). The consistent and contrary between results of this study and findings of above workers could be attributed to the differences in the management system, control practice in farms, and seasonal differences in the study area (Jegede et al., 2007). In addition, the high prevalence observed in local chickens is believed to be associated with the free-range nature of the local birds which roam from place to place in search of food by scavenging on superficial layer of the soil which contains various arthropods and earthworms that serve as the intermediate hosts for most helminths of Poultry (Idika, et al., 2016).

The study's results revealed that, nematodes, cestodes and coccidia spp. were the most common intestinal parasites of chickens. These results are in accordance with the works of Luka and Ndams,(2007) in Zaria, Junaidu et al., (2014) in Nigeria, and Kumar et al. (2015) in India, who reported that, cestodes and nematodes were implicated as the major cause of helminth infection in domestic chickens. Cestodes generally undergo an indirect mode of transmission where they make use of

intermediate host such as ants, grasshoppers, and beetles to perpetuate their transmission (Asumang et a., 2019). These organisms serve as food for scavenging birds and hence transmit the infective stage of the parasites to the bird upon ingestion (Idika, et al., 2016). The high prevalence rate of gastrointestinal infection also indicates the availability of their infective stages in the study area and the ability of the infective stages to withstand environmental conditions for a long time before they are taken in by the host (Asumang et al., 2019).

Among 170 (69.11%) infected birds with gastrointestinal parasites, the prevalence rate according to species identified was 21.95%, 14.63%, 10.57%, 9.76%, 6.10% and 6.10 for *Ascaridia galli*, and *Eimeria* spp., *Raillietina echinobothrida*, *Raillietina cesticillus*, *Capillaria* spp. and mixed infection respectively (Table 1). Significant differences ($P < 0.05$) were observed among prevalence rates of parasites species. On the basis of parasites types, among nematodes parasites *A. galli* (21.95%, %) and in cestodes, *Raillietina echinobothrida*. (10.57%) were the most prevalent parasites species. These results are in line with previous studies (Jegede et al., 2015; Negbenebor and Ali, 2018; Asumang et al., 2019; Saraiva et al., 2020). The higher prevalence of *A. galli* parasite in local chicken is in consonance with several studies which indicate the species as the commonest and most important helminth infection of poultry (Cervantes-Rivera et al., 2006; Ohaeri and Okwum, 2013). This is not surprising as *A. galli* have a direct life cycle and their eggs are very resistant to the environment conditions. The eggs are passed out in the faces of the host and develop into the infective stage in the open, contaminating feed and water source, and a new hosts become infected when they ingest the infective eggs from these sources (Ybañez et al., 2018). In the deep litter system, the eggs can probably remain infective for long period depending on management practice, the temperature, humidity, pH, and ammonium concentration, feed and water sources of birds can easily be contaminated, as farm handlers can transport the eggs of these parasites from other sources to the locality of birds (Asumang et al., 2019).

The infection rate in chicken with cestoda was 20.33% out of all infected birds and was represented by *Raillietina echinobothrida* and *Raillietina cesticillus*. *Raillietina* genus and these species are reported in many parts of the world with different rate of infection (Iqbal et al. 2018). Species of *Raillietina* need intermediate hosts (gastropod mollusk and ants) to complete their life cycle.

Therefore, the differences in prevalence rate can be influenced the availability of intermediate hosts, hygiene and local climate (Iqbal et al., 2018).

Eimeria spp. are one of the most important protozoan parasites of poultry, both in terms of distribution, frequency, and economic losses (McDougald, 1997). They are passed through a chicken's droppings and contaminated the environment. The common clinical signs of coccidiosis in birds are loss of appetite, blood or mucus in the feces, diarrhea, dehydration, and even death (Allen et al., 2002). Local chicken are vulnerable to the transmission of this parasite through the transportation of personnel and equipment (McDougald, 1997). However, the prevalence of most of the parasitic diseases in poultry including *Eimeria spp.* seems to have reduced significantly in commercial poultry production systems due to improved housing, hygiene and management (Permin and Hansen 1998) but, its continue to be of great importance in deep-litter and free-range systems of poultry rearing (Kumar et al., 2015). In current study, the prevalence rate *Eimeria spp.* infections in local chicken was 14.63%. These results are in line with findings of Negbenebor and Ali (2018) who studied prevalence of gastro-intestinal parasites of local chickens (*Gallus Gallus Domestica*) in Kano, Nigeria and reached to similar results. The prevalent *Eimeria spp.* infection among local chicken may be due to seasonal variations, management practices, biosecurity, and ecological conditions of the study areas.

In mixed infection, Out of total 246 chickens examined, 15 (6.1%) birds were found infected with more than one parasites, this prevalence rate is lower than findings reported by Jegede (2015) who reported higher percentage of mixed infection in local birds in Nigeria. This could be attributed to managemental practices, breeds and size of samples examined. Moreover, Afia et al. (2019) suggested that, the mixed infection of two or more species of parasites per bird could be due to food preference at a particular time.

The effect of characteristic/ risk factors on distribution of gastrointestinal parasites prevalence in local chicken are presented in Table 2. As shown, the higher rate of infection was recorded in bird of age group less than 5 months (30.39%); whereas, lower infection rate(17.89%) in birds of age group up to 12 months. There were no significant differences ($P < 0.05$) between prevalence rate and age factor. These results are in contrast with findings of Jegede et al. (2015) who reported that there were

significant differences ($p < 0.05$) among the age groups, with highest infection rate occurring in grower birds. This could be attributed to the existing maternal immunity in the chicks and the longer exposure of the older birds to both helminth ova and coccidian oocyst from the environment.

On the basis of sex, the results revealed that, the infection rate in males (45.53%) was significantly ($P < 0.05$) higher than females (23.58%) as depicted in Table 2. These results are in accordance with findings of Jegede et al. (2015) and in contrary with findings of Uhuo et al. (2013) who reported that the infection rate in females higher compared to males. The higher prevalence rate of infection in males may be attributed to behavior and biological factors.

In Yemen, there are two breeds of indigenous chicken. One of them is called "*Albaladi Aljabali*" and is located in the high mountains and uplands. The second breed is called "*Albaladi Alsehili*" which is located in the lowland coastal areas (Al-Mamari, 2008). In this study, the gastrointestinal parasites were more prevalent in *Albaladi Aljabali*(35.37%) compared to *Albaladi Alsehili* (16.67%) and Hybrid breeds (4.07%). Statistically, there were no significant differences ($P > 0.05$) in prevalence rate of infection among local breed chicken examined (Table 2). These results are in parallel with findings of Zalizar et al., (2021) who studied prevalence of gastrointestinal helminths in Indonesian native chickens, and its impact on egg production. The differences in prevalence rate in Yemeni chicken breeds may be due to genetical and environmental factors.

In present study, Month variation (season) was significantly ($P < 0.05$) effect on distribution of parasites in local chicken, and the higher prevalence rate of infection was recorded in month of March (17.07%) and the lower rate in month of January (9.76%) as indicated in Table 2. These variations could be due to differences in local environmental conditions, which support larval development and facilitate transmission of infective stage to new host. The impact of geographical zone in distribution of gastrointestinal parasites also was investigated, and the results were revealed that, the higher the prevalence rate of GIT parasites in chicken was recorded in Anis and Dhamar city(16.67%); whereas; the lower rate in Myfaa area (10.93). There were significant differences ($P > 0.05$) in prevalence rate of infection among study localities/areas. The reason behind that could be attributed to geographical characteristics of areas, availability of intermediate hosts.

The results of logistic regression analysis for assessing the association between prevalence rate of gastrointestinal and risk factors in local chicken are presented in Table 3. As shown, logistic regression demonstrated that there association between prevalence rate and sex (OR= .377; 95%CI: .216-.656; P= .001), Breed (OR= 1.366; 95%CI: .216-.656; P= 0.024) and parasite species (OR= 0.058; 95%CI:0.026-.130; P= 0.000); while, none with other risk factors investigated.

The correlation between infection prevalence rate, season and climatic conditions are presented in Fig. 1. As shown there is slightly fluctuation in prevalence rates and the higher rate recorded in month of March and April when climatic condition is moderate (21.5 and 21.5°C), (53 and

53%) and (49.4 and 186.9 mm) for Temperature, Relative humidity and rainfall respectively.

CONCLUSION

It could be concluded from this study, gastrointestinal parasites infections are prevalent among local breed chickens in study areas. Prevalence rate of gastrointestinal parasites infections is influenced by sex, breed of chicken, seasons (month variation) and study area. An epidemiological control programme should be put in place to minimize worm infections and their effects on local chicken. Further studies on the prevalence of gastrointestinal parasites in chicken need to be elucidated for improved intensive egg and poultry meat productions.

Table 1. Prevalence of gastrointestinal parasites identified in local breeds chicken in Dhamar city(n=246)

Parasite	No. of birds infected	Prevalence %	P value
<i>Ascaridia galli</i>	54	21.95	0.000
<i>Railletina cesticillus</i>	24	9.76	
<i>Railletina echinobothrida</i>	26	10.57	
<i>Eimeria spp.</i>	36	14.63	
<i>Capillaria spp.</i>	15	6.10	
Mixed infection	15	6.10	
Overall prevalence	170	69.11	

Table 2. Distribution of gastrointestinal parasites in local breeds chicken according to characteristics of chicken and environmental factors(n=246)

Variable Factor	Categories	No. of infected birds	Prevalence%	P value
Age	>5months	76	30.89	0.213
	10 m	50	20.33	
	<12M	44	17.89	
Sex	Male	112	45.53	0.000
	Female	58	23.58	
Breed	<i>Albaladi Aljabali</i>	87	35.37	0.152
	<i>Albaladi Alsehili</i>	41	16.67	
	Hybrid breeds	10	4.07	
Month variation	January	24	9.76	0.000
	February	31	12.60	
	March	42	17.07	
	April	41	16.67	
	May	31	12.60	
	June	19	7.72	
Area/ localities	Anis	41	16.67	0.002
	Centre of Dhamar	36	14.63	
	Haran	36	14.63	
	Myfaa	27	10.98	
	Mariaa	11	12.19	
Overall prevalence		170	69.11	

Table 3. Logistic regression analysis results for association between prevalence of gastrointestinal parasite in chicken and associated risk factors(n=246)

Variable/ Factor	Categories	Infected birds	Prevalence %	OR	95% CI	P value
Age	>5months	76	30.89	1.32	.950-1.837	.098
	10 m	50	20.33			
	<12M	44	17.89			
Sex	Male	112	45.53	.377	.216-.656	.001
	Female	58	23.58			
Breed	<i>Albaladi Aljabali</i>	87	35.37	1.366		0.024
	<i>Albaladi Alsahili</i>	41	16.67			
	Hybrid breeds	10	4.07			
Month variation	January	24	9.76	1.151	.972-1.362	0.102
	February	31	12.60			
	March	42	17.07			
	April	41	16.67			
	May	31	12.60			
	June	19	7.72			
Area/ localities	Anis	41	16.67	1.094	.936-1.279	0.260
	Centre of Dhamar	36	14.63			
	Haran	36	14.63			
	Myfaa	27	10.98			
	Mariaa	11	12.19			
Parasite species	<i>Ascaridia galli</i>	54	21.95	0.058	.026-.130	0.000
	<i>Railletina cesticillus</i>	24	9.76			
	<i>Railletina echinobothrida</i>	26	10.57			
	<i>Eimeria spp.</i>	36	14.63			
	<i>Capillaria spp.</i>	15	6.10			
	Mixed infections	15	6.10			

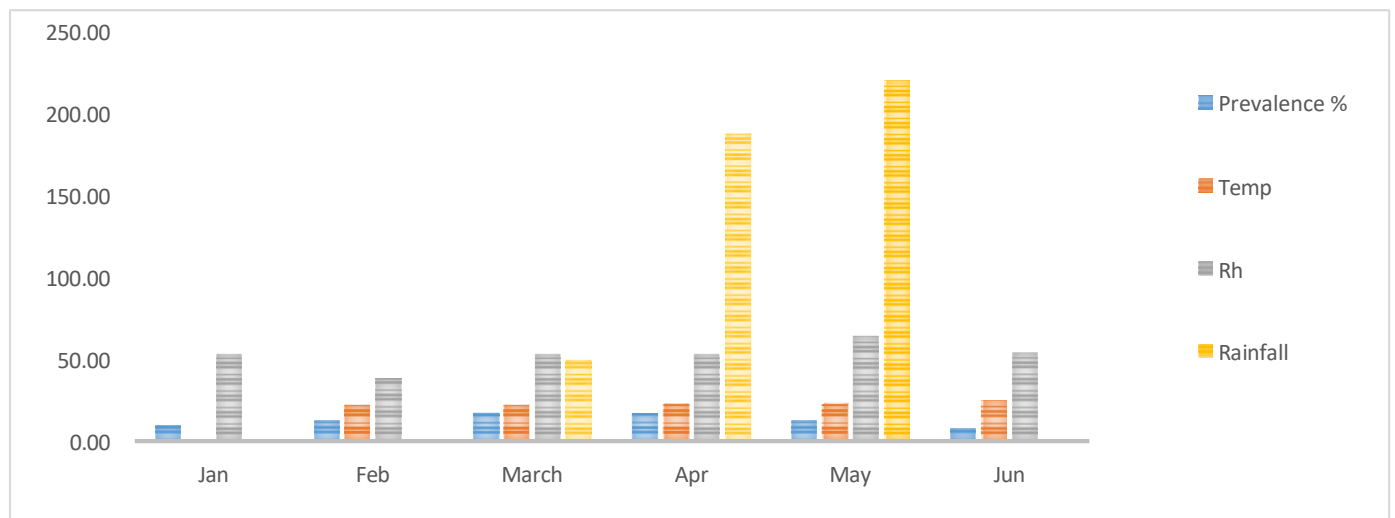


Fig.2. Correlation between parasites prevalence and season and weather in local chicken in study areas

ETHICAL APPROVAL

This study was conducted after approval by Faculty of Agriculture & Veterinary Medicine, Dhamar University, Yemen.

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COMPETING INTERESTS

Authors have declared that no competing interests exist.

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ديدان القناة الهضمية في السلالات المحلية للدجاج في مدينة ذمار

الملخص

أجريت هذه الدراسة بهدف التعرف على الطفيليات المعوية التي تتطفل على الدجاج المحلي التي يتم ذبحها في اسواق الدجاج بمدينة ذمار وتحديد نسبتها. تم جمع وفحص ما مجموعه 246 عينة براز من القناة الهضمية للدجاج المذبوح في الفترة من يناير إلى يونيو 2023، باستخدام طرق المسحة المباشرة والتعويم (كلوريد الصوديوم) للبحث عن وجود بيوض ومتكيسات الطفيليات في الجهاز الهضمي للدجاج المفحوص، كشفت النتائج أنه من 246 عينة تم فحصها، 170 (69.11%) وجدت إيجابية لاحدى أو أكثر من أنواع من الطفيليات، وكانت نسبة الإصابة مرتفعة بين الذكور (45.53%) مقارنة بالإناث (23.58%). أنواع الطفيليات التي تم التعرف عليها هي: *Ascaridia Galli* (21.95%)، *Raillietina echinobothrida* (10.57%)، *Eimeria spp.* (14.63%)، *Capillaria spp* (6.10%)، و *Raillietina ceticillus* (9.76%)، والعدوى المختلطة (6.10%)، لوحظت فروق معنوية ($P < 0.05$) بين معدلات انتشار الطفيليات التي تم التعرف عليها. كما اظهرت النتائج ايضا ان توزع الإصابة بالطفيليات على أساس عوامل الخطورة، ان أعلى نسبة إصابة وجدت في الفئات العمرية أقل من 5 أشهر (30.89%)، في سلالة البلدي الجبالي (35.37%)، في شهر مارس (17.07%)، وفي مديرية انس (16.67%)؛ بينما سجلت أقل نسبة إصابة في الفئة العمرية حتى 12 شهر (17.89%)، في السلالات الهجينة (4.07%)، في أشهر يونيو (7.72%)، وفي مديرية ميفع (10.98%). لوحظت فروق معنوية ذات دلالة إحصائية ($P < 0.05$) بين معدل الانتشار والجنس واختلاف الشهور (الموسم) والمنطقة (المديريات) مع نسبة الإصابة؛ بينما لم يلاحظ مع بقية عوامل الاخرى. أظهرت نتائج تحليلات الانحدار اللوجستي وجود ارتباط كبير بين نسبة الإصابة بطفيليات الجهاز الهضمي والجنس ($OR = 0.377$ ؛ $95\% CI: 0.216-0.656$)؛ $P = 0.001$ ، والسلالات ($OR = 1.366$ ؛ $95\% CI: 0.216-0.656$)؛ $P = 0.024$)، وأنواع الطفيليات ($OR = 0.058$ ؛ $95\% CI: 0.026-0.130$)؛ $P = 0.000$. نستنتج من هذه الدراسة أن الإصابة بالطفيليات المعوية منتشرة بين الدجاج المحلي في مناطق الدراسة. لذا يجب وضع برنامج مكافحة وبائي للحد من الإصابة بالطفيليات وتأثيرها على إنتاج الدجاج في منطقة الدراسة والبلد بشكل عام.

الكلمات المفتاحية: الدجاج، طفيليات القناة الهضمية، ذمار، اليمن

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Original article

Spatial-Temporal Distribution and Some Associated Factors of Rabies in Dhamar Governorate, Yemen: A Retrospective Study 2011–2017

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ABSTRACT

Rabies is a fatal zoonotic disease of mammals, including humans. It remains a public health problem in many Asian and African countries, including Yemen. This study aimed to describe the spatial-temporal distributions and associated risk factors of rabies in Dhamar governorate, Yemen. Data on reported rabies cases for the years 2011 to 2017 was obtained from the National Rabies Control Program (NRCP)-Unit of Dhamar Governorate. Three rabies indicators were analyzed, including total bites, positive bites, and the number of deaths. The association of rabies indicators with reporting year, month/season, district, as well as the age and gender of the victims, was assessed. A total of 13,706 bites, 2,555 positive bites, and 49 deaths due to rabies were reported in Dhamar governorate between 2011 and 2017. The annual incidence was averaged at 111.64 bites, 20.80 positive bites, and 0.402 deaths per 100,000 capita. Incidence in some rural areas was as high as in urban areas, and it was significantly higher in the eastern districts than in the western districts. The highest exposure occurred in winter (December–February) while the lowest exposure occurred in summer (June–August). The incidence was significantly higher in males (OR \geq 2.36) and in age strata 5-14 years (OR \geq 2.42). Rabies is still endemic in Dhamar governorate, and several factors affect exposure to the disease. Factors associated with higher exposure in some districts need to be clarified, in particular the determination of the local wildlife reservoir(s) and its distribution/mobility. Study the incidence of rabies in animals, like bovine and equine species, and their role in transmission of the disease is also encouraged.

INTRODUCTION

Rabies is a zoonotic disease that has been known for thousands of years (Gnanadurai et al., 2013). It is caused by *Lyssavirus* genotype 1 of the family *Rhabdoviridae* (Warrell, 2004). Rabies is a fatal disease of mammals, including humans (Singh et al., 2017); nevertheless, all warm-blooded animals are also susceptible to infection (Oyda and Megersa, 2017). The rabies virus maintains itself in the environment in wildlife reservoirs that vary between contents and subcontinental regions, including dogs, foxes, wolves, hyenas, raccoons, and bats (Warrell, 2004). Dogs are the main vector, and approximately

95% of the human rabies cases arise from dog attacks (WHO., 2018). The virus presents in the saliva of rabid animals, and is most commonly transmitted by the bites of rabid animals (Singh et al., 2017). Administration of post-exposure prophylaxis (PEP) immediately after exposure to the bite was reported to be highly effective, while the disease is invariably fatal after the appearance of clinical manifestations (Warrell, 2004).

Rabies is a neglected tropical disease that mostly affects vulnerable people and poor communities (WHO, 2023). Human rabies is

underestimated due to several factors, such as an immature reporting system and a lack of diagnostic infrastructure (WHO., 2018). Annually, 59,000 human deaths occur globally, with a one death case every 10 minutes or less. It mostly affects Asia and Africa, where 59.6% and 34.6% of the deaths, respectively, occur (WHO., 2018). Annually, 29 million PEPs are received, with an average cost of 108 US dollars for each. The annual global burden of rabies was estimated at 8.6 billion US dollars (WHO, 2023). Elimination of rabies is feasible, and rabies has come under control in most of the developed countries, largely through the vaccination of pet animals, in particular dogs (Gnanadurai et al., 2013, Wallace et al., 2017). In 2016, the World Organization for Animal Health (OIE), the WHO, and the Food and Agriculture Organization (FAO), as well as many other non-governmental organizations, set the goal of eliminating dog-mediated human rabies deaths by 2030 (Wallace et al., 2017).

Control or elimination of rabies in a particular region requires prior knowledge of its epidemiology in that region. Several factors affect the incidence of rabies, including, but not limited to, the presence of wildlife reservoirs, their distribution and mobility (Aiyedun et al., 2017), dog and human densities and the dog-to-human ratio (Babaniyi et al., 2016, FAO., 2014), human behaviors (WHO., 2018), socio-economic factors (Bonilla-Aldana et al., 2022), transportation, and the presence of roads (Song et al., 2009). Accordingly, the incidence of rabies may not evenly distributed over time or space and, in some instances, tend to cluster (Bonilla-Aldana et al., 2022). Spatial temporal distribution allows the identification of regions/periods with higher exposure and paves the way to assign the determining factors.

Little is known about the epidemiology of rabies in Yemen particularly in Dhamar governorate. Nationally, up to 7,000 bites and at least 30 deaths were reported annually (Al-Shamahy et al., 2013). Here, we aimed to describe the spatial-temporal distributions and some associated factors of rabies in Dhamar governorate and to highlight the rabies problem accordingly.

MATERIALS AND METHODS

Study area and population

Dhamar governorate is located in the central west region of Yemen, about 100 km south of the capital, Sana'a, and between latitudes 14° - 15°N and longitudes 43.30° - 44.50°E. Dhamar is an agriculture governorate that produces some crops like potatoes, corn, and others. It also harbors a large number of

animals, especially sheep and cattle. Topologically, Dhamar is a mountainous area that is elevated between 760m and 2848 m above sea level. According to the last official census conducted in 2004, the population of Dhamar governorate was 1,330,108 capita. Administratively, the governorate is divided into 12 districts (NIC, 2018) and can be separated by the longitude E44.075°E into an eastern part (Al-Hada, Jahran, Dhowran, Al-Manar, Anss, Maeffa'at Anss, Dhamar City, and Maghreb Anss) and a western part (Jabal Al-Sharq, Utmah, Wisab Al-A'ali, and Wisab Al-Safel).

Data Collection

Data on rabies incidence for the years 2011 to 2017 were obtained from the National Rabies Control Program (NRCP)-Unit of Dhamar Governorate. It consists of monthly records of numbers of positive bites, negative bites, unknown bites, and total bites for males and females, as well as the number of deaths for different age strata (0–4, 5–14, 15–40, and >41 years). The data presented at the district level with records of two districts, Wisab Al-A'ali and Wisab Al-Safel, merged under the name Wisabaen. The estimated population size of Dhamar governorate for the targeted years was obtained from the National Information Center (NIC)-Yemen (NIC, 2018). The population fraction contributed by each district to the overall governorate population was obtained from the last official population census (2004) (NIC, 2018).

Data analysis

The obtained data was tabulated in MS Excel sheet. Assuming a constant growth rate of the district population, the annual population size at the district level was projected from the governorate's annual population size and the district population fraction.

Three rabies indicators were studied, including total bites, positive bites, and the number of deaths. Temporal and spatial distributions of the rabies indicators were expressed as annual incidence per 100,000 capita at the governorate and district levels, respectively. Mapping spatial distribution was performed using Epi-Info™ 7.2.4.0 (CDC, Atlanta).

The associations of the involved variables with month/season, age strata, and gender were expressed as percentages using the total count of each variable as a denominator. The odd ratio (OR) was also calculated to reflect the effect of population size.

The significance of the differences was judged using the Chi-square test (χ^2) in Prism (GraphPad software version 9, San Diego, CA, USA). P-values less than 0.05 were considered statistically

significant.

RESULTS

Annual incidence of rabies indicators in Dhamar governorate

A total of 13,706 bites, 2,555 positive bites, and 49 deaths due to rabies were reported in Dhamar governorate between 2011 and 2017. The annual incidence of total bites in Dhamar governorate ranged between 89.43 bites/100,000 capita in 2014 and 161.41 bites/100,000 capita in 2016, and averaged to 111.64 bites/100,000 capita (Figure 1). The annual incidence of positive bites ranged between 14.97/100,000 capita in 2011 and 32.21/100,000 capita in 2016, and averaged to 20.80/100,000 capita. The annual incidence of death due to rabies ranged between 0.172/100,000 in 2014 and 0.686/100,000 capita in 2017 and averaged to 0.402/100,000 capita. Significant differences were observed between the studied years regarding the number of total bites (p value <0.0001) and positive bites (P value <0.0001), but not for the number of deaths (P value = 0.0923).

Seasonality

Comparing the number of total bites and positive bites on a month/season basis showed significant differences between months/seasons. Exposure was higher in winter (December to February) and lower in summer (June to August), as shown in Table 1. On the other hand, differences in the number of deaths were not significant.

Spatial distribution of rabies indicators in Dhamar governorate

The presented data showed significant differences in the distribution of the three rabies indicators between districts of Dhamar governorate. Anss district showed the highest incidence of the three indicators (290.5 bites, 49.57 positive bites, and 0.914 deaths/100,000 capita). On the other hand, Wisabaen showed the lowest incidence of total bites and positive bites (10.34 total bites and 2.57 positive bites/100,000 capita), while death due to rabies was not reported from Maghreb Anss and Maeffa'at Anss, as shown in Figure 2. For the three rabies indicators, there was a significant difference (P value <0.001) between eastern districts (160.91 bites, 28.59 positive bites, and 0.552 deaths /100,000 capita) and western districts (36.5 bites, 8.98 positive bites, and 0.167 deaths/100,000 capita). The incidence of bites and positive bites in Anss, a rural district, was significantly higher than that in Dhamar city (174 bites, 25.6 positive bites, and 0.435 deaths/100,000

capita) the main urban area in the governorate.

Age of the victims

The present findings showed significant differences between reported age strata over the three rabies indicators. The highest exposure was associated with the age strata 5 to 14 years old, with ≥ 2.42 times higher than the other strata, as shown in Table 2.

Gender of the victims

The presented findings showed that exposure of males to bites and positive bites (approximately 70%) was significantly higher than that in females (approximately 30%), as shown in Table 3. For both indicators, the odd ratio showed that exposure of males was approximately ≥ 2.36 times higher than exposure of females. The genders of the dead victims were not specified and, thus, not shown.

DISCUSSION

Analysis of the incidence of bite/rabies cases and evaluating the major associated risk factors are essential to establish a rabies control strategy. The present study highlights the epidemiology of rabies in Dhamar governorate and provides insights into the incidence of bites, rabid bites, and deaths due to rabies in Dhamar governorate, Yemen. The spatial-temporal dynamics of the disease and its association with the age and gender of the victims were assessed. In the present study, average animal bites exposure was 111.64/100,000/year and ranged between 89.43/100,000 in 2014 and 161.41/100,000 in 2016 in Dhamar governorate. The reported rate is at the lower margin of the global estimation of the annual incidence of dog bites cases, which ranged between 100 and 5,000 bites per 100,000 capita (WHO., 2018). In this way, an annual incidence of 42.4, 39.6, and 1500 bites per 100,000 capita were reported from Zambia, Uganda, and the USA, respectively (Fe`vre et al., 2005, Babaniyi et al., 2016, Hiby et al., 2017).

In the current work, exposure to positive bites in Dhamar governorate was averaged at 20.80 per 100,000 capita per year and ranged between 14.97/100,000 capita in 2011 and 32.21/100,000 capita in 2016. Comparable findings were reported from Ethiopia, where exposure to rabid bites was 35.8 to 89.8 per 100,000 capita in Tigray (Teklu et al., 2017) and 1.27 to 4.6 per 100,000 capita in Gondar (Yibrah and Dامتie, 2015). At the national level in Ethiopia, the annual incidence of rabid bites was estimated at 12 rabid bites per 100,000 (Beyene et al., 2018). Similarly, exposure to a rabid bite was

estimated at 27/100,000 in New York, USA, and 58/100,000 in Tanzania. Higher rates were reported by active surveillance, for example, rabid bites was estimated at 234/100,000 capita in Kenya (Yibrah and Damtie, 2015).

In the current study, annual mortality due to rabies in Dhamar governorate ranged from 3 deaths (0.172/100,000) in 2014 to 13 deaths (0.686/100,000) in 2016, with an average of 0.402 deaths/100,000 capita. This finding is lower than that reported in Ethiopia, Kenya, and Tanzania, which were estimated at 1.6, 2.5, and 4.9 rabies deaths per 100,000 capita, respectively (Beyene et al., 2018, Taylor et al., 2017). However, rabies in Dhamar governorate and in Yemen is largely underestimated due to a shortage of reporting systems (Al-Shamahy et al., 2013).

Significant differences were found in the incidence of bites/positive bites between months/seasons in Dhamar governorate, which peaks in December–February. This is in agreement with the findings reported by Yibran and Damtie (2015) who showed higher exposure in the fall and winter months (approximately 60%) and lower exposure in the spring and summer in Gondar, Ethiopia (Yibrah and Damtie, 2015). On the other hand, higher exposure to dog bites (60%) was reported to occur between June and October in Zaria, Nigeria (Ehimiyein et al., 2014) and between March and May (40%) in Bhutan (Tenzin et al., 2011).

The present findings showed that 36.73% of the mortalities occurred from September to November. This is in agreement with previous reports from Ethiopia and elsewhere showing that a higher incidence of rabies occurs in late summer and fall and was attributed to the higher mobility of the wild animals in search of food and mating partners during this period (Oyda and Megersa, 2017). Similarly, a study in Zimbabwe showed that the highest incidence of human rabies occurs during the dry season from July to November (Pfukenyi et al., 2007).

In the present work, a significant difference in the incidence of rabies was observed between Dhamar districts, with a higher incidence in the eastern districts. This may be linked to the presence of wildlife animals, including wolves, haynes, hedgehogs, jackals, foxes, leopards, and caracals, that have been reported in Dhamar, especially in the eastern part, due to the presence of water springs in this region (Beck, 1990, USAID-Yemen., 2013). Nevertheless, Utmah district in the western part has also been declared a protected area since June 2, 1999 (USAID-Yemen., 2013). Wild life is a central component of rabies epidemiology, from which

infection is transmitted to domestic animals, especially dogs, and humans (Aiyedun et al., 2017). In this regard, the red fox (*Vulpes vulpes*) and golden jackal (*Canis aureus*) have been reported as the main reservoirs of rabies in Yemen and surrounding countries (WHO., 2018). Additionally, bites and transmission of rabies by domestic animals, such as bovines, have also been reported.

However, dogs remain the main attacking animals and the main source of rabies for humans (Babaniyi et al., 2016). Increases in dog and human densities were associated with an increase in rabies transmission. Hence, the incidence of rabies was significantly higher in urban areas than in rural areas (Beyene et al., 2018). No data on the size of the dog population at the district or governorate levels was available. The dog population in Yemen was estimated to be more than 1,000,000, with 10–20% of them owned (Al-Shamahy et al., 2013). The size/management of the dog population, the human-to-dog ratio, the availability of eatable food (for example in garbage contents and carcasses of dead animals/birds), and the mass immunity of the dog population (induced by vaccination) are some of the underlying factors affecting rabies epidemiology (FAO., 2014).

Notably, in the present study, the incidence of bites and positive bites in some rural areas was as high as in urban areas or even higher. The two districts with the highest incidence of total bites, Dhamar city and Anss, contain about 60% of the commercial poultry farms/sheds in Dhamar governorate (Al-Mamari, 2008). Indeed, a significant positive correlation was found between the number of poultry farms/sheds and the number of total bites at district levels (data not shown).

In urban areas, the vast majority of the dogs are stray (Al-Shamahy et al., 2013), while dogs are frequently owned in rural areas to guard cultivations, especially Qat trees which are widely grown in the eastern districts of Dhamar governorate. These are some of the factors with an expected link to the dog population and spread of rabies. Other factors that were reported to affect the incidence of dog bites/rabies include land use, mobility, and the presence of roads (Babaniyi et al., 2016).

In the current investigation, the exposure of age strata 5 to 14 years was ≥ 2.42 higher than the other strata for the three rabies indicators. Those aged ≤ 14 years represented 57% to 63% of the total victims. Previous findings from Yemen showed that the age strata ≤ 10 years represented 56.1% of the victims of the positive bites (Al-Shamahy et al.,

2013). Compatible findings were reported from Tigray-Ethiopia and from Oman, where 56% and 52% of the bitten victims were in age strata 0–15 and 0–19 years, respectively (Abebe et al., 2015, Al-Abaidani et al., 2015). Lower exposure was also reported from Ethiopia, Zimbabwe, and Ghana, where 38.5% to 47.9% of the bites were reported in the age strata <15 years (Yimer et al., 2002, Yibrah and Damtie, 2015, Pfukenyi et al., 2007). On the other hand, a higher exposure of this age strata (0–14 years) to animal bites was reported in Iraq, where it received 63% of the total bites (Horton et al., 2013). The higher exposure of this age strata may be attributed to the higher outdoor activity and close contact with animals, as previously reported by others (Al-Abaidani et al., 2015).

In the present work, males represented 70.66%, while females represented 29.34% of the bitten individuals. Regarding positive bites, males and females represent 69.7% and 31.3%, respectively, of the victims. This is in fine agreement with a previous report from Yemen, where males

represented 68.9% of the victims bitten by rabid animals (Al-Shamahy et al., 2013). Similarly, males constitute 70.1% of the bitten victims in Oman (Al-Abaidani et al., 2015). Gender-attributed differences in the exposure to animal bites decrease in some countries like Ethiopia, Bhutan, and Ghana. Out of the bitten victims, males represented 54% to 63% in Ethiopia (Yibrah and Damtie, 2015, Abebe et al., 2015, Aleme and Glmeskel, 2017, Teklu et al., 2017, Yimer et al., 2002, Deressa et al., 2010); 62% in Bhutan (Tenzin et al., 2011); and 50.3% in Techiman, Ghana (Punguyire et al., 2017). On the contrary, 89%, 80%, and 73.8% of the bitten victims in Iraq, India, and Zimbabwe, respectively, were males (Horton et al., 2013, Babaniyi et al., 2016, Pfukenyi et al., 2007). Gender-related differences in exposure to bites may be attributed to differences in outdoor activities between males and females.

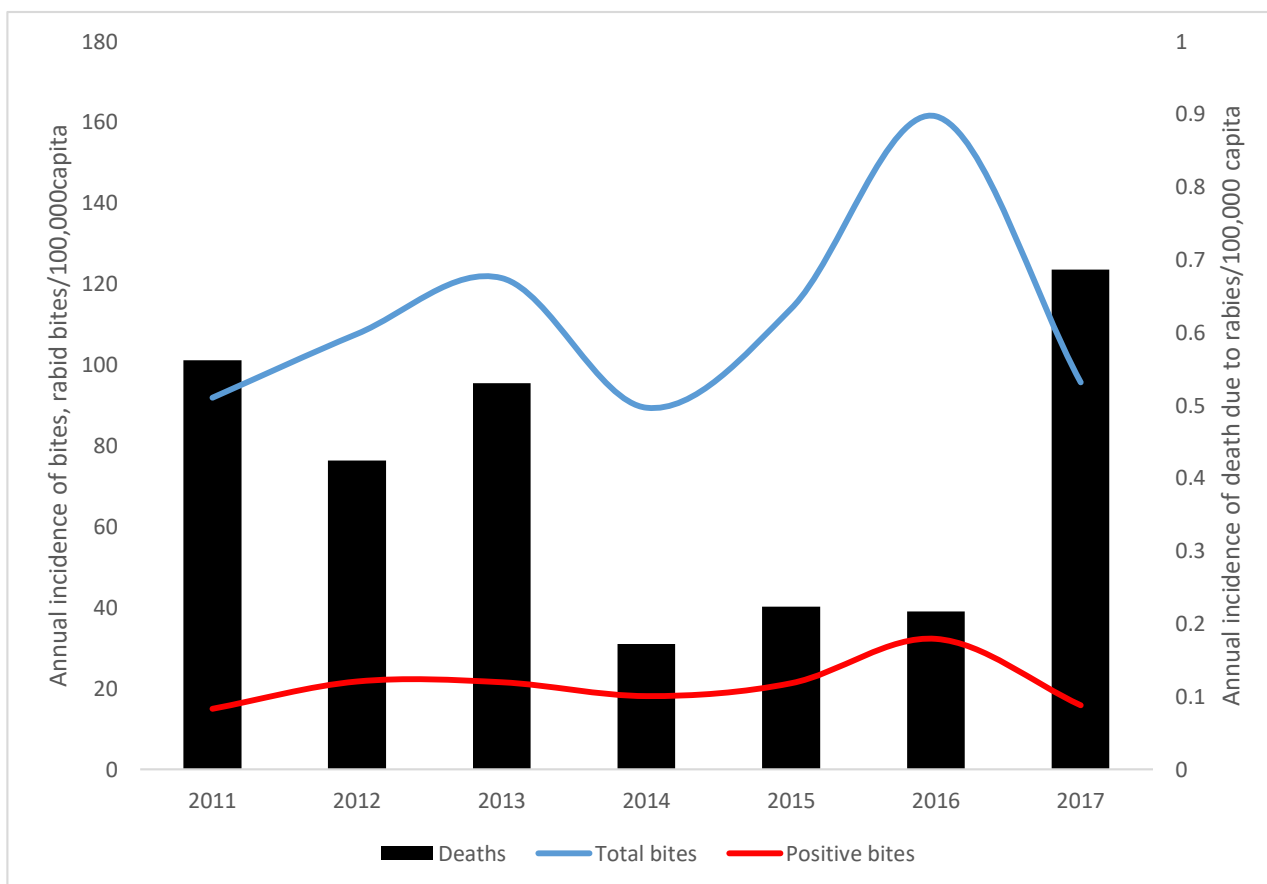


Fig.1. Temporal distribution of rabies cases in Dhamar governorate for the period from 2011 to 2017

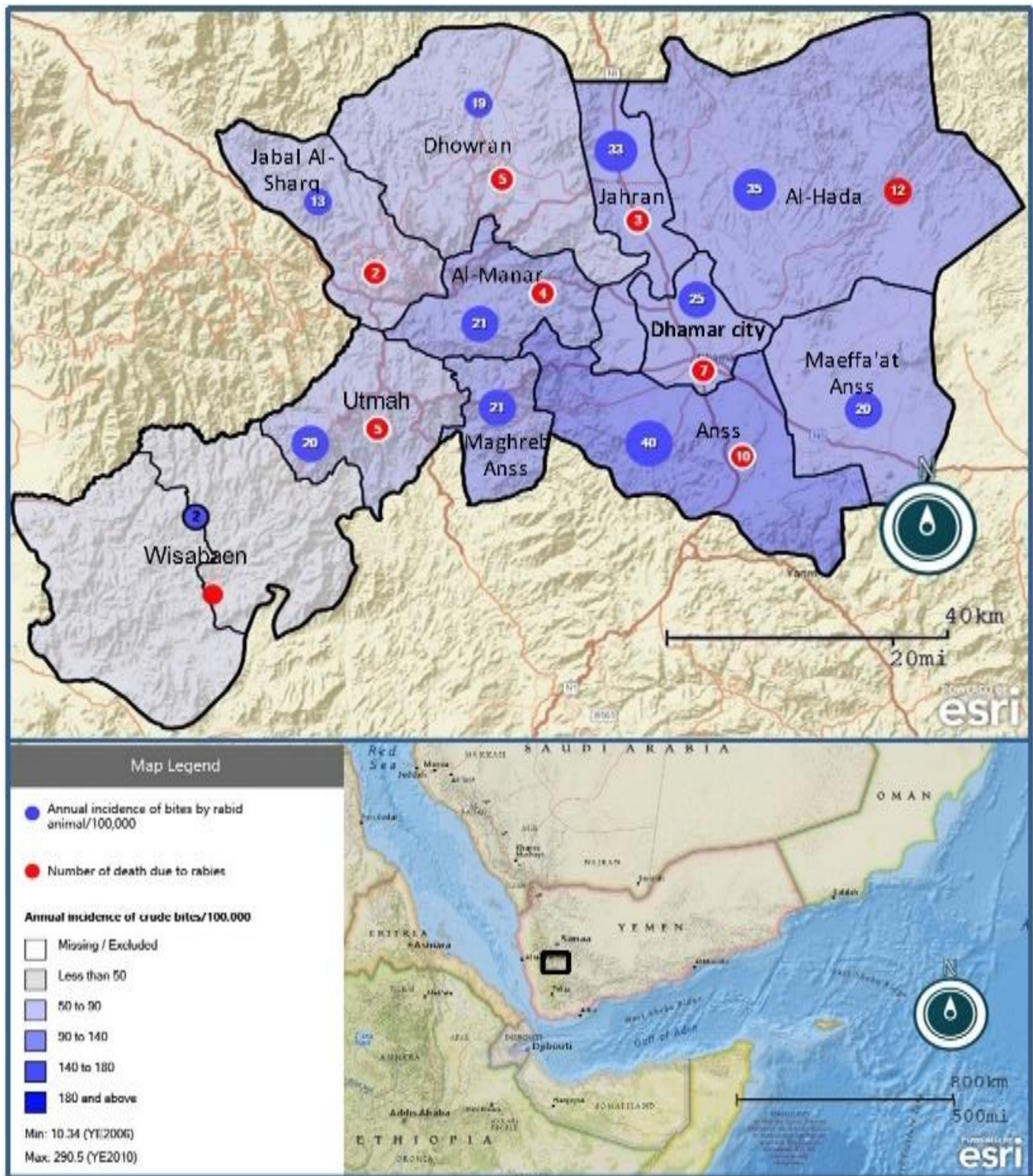


Fig 2. Spatial distribution of rabies in Dhamar governorate at district level. The annual incidence of total bites (choropleth) and of positive bites (case cluster in blue), as well as the total number of deaths due to rabies (case cluster in red). The map was constructed using Epi-Info™ 7.2.4.0. Source of the Map: National Geographic, Esri, DeLorme, HERE, UNEP-WCMC, USGS, NASA, ESA, METI, NRCAN, GEBCO, NOAA, IPC.

Table 2: Comparison of numbers of animal bites, positive bites, and death due to rabies over ages of the victims

Age strata	Population*	Total bites (%; OR; CI95%)	Positive bites (%; OR; CI95%)	Deaths (%; OR; CI95%)
0_4 years	277,734	1769 (12.91; 0.78; 0.74-0.82) [∇]	386 (15.11; 0.94; 0.84-1.05)	6 (12.24; 0.74; 0.31-1.73)
5_14 years	440,031	6195 (45.2; 2.47; 2.39-2.55) ^Δ	1212 (47.44; 2.68; 2.48-2.9) ^Δ	22 (44.9; 2.42; 1.38-4.25) ^Δ
15_40 years	755,519	3906 (28.5; 0.52; 0.5-0.54) [∇]	714 (27.95; 0.51; 0.47-0.55) [∇]	14 (28.57; 0.52; 0.28-0.97) [∇]
>40 years	272,265	1836 (13.4; 0.84; 0.8-0.88) [∇]	243 (9.51; 0.57; 0.5-0.65) [∇]	7 (14.29; 0.9; 0.41-2.01)
Total	1,745,549	13,706	2,555	49

*: Population size of the middle year (2014), [∇]: Exposure is significantly lower than that in other strata

^Δ: Exposure is significantly higher than that in other strata

Table 1. Comparison of numbers of animal bites, positive bites, and death due to rabies at level of season

Season	Population*	Total bites (%; OR; CI95%)	Positive bites (%; OR; CI95%)	Death (%; OR; CI95%)
Dec. -Feb.	1,745,546	3612 (26.35; 1.08; 1.04-1.12) ^Δ	698 (27.32; 1.13; 1.03-1.23) ^Δ	11 (22.45; 0.87; 0.44-1.7)
Mar.-May	1,745,546	3416 (24.92; 1; 0.96-1.04)	686 (26.85; 1.1; 1.01-1.2) ^Δ	7 (14.29; 0.5; 0.22-1.11)
June-Aug.	1,745,546	3282 (23.95; 0.95; 0.91-0.98) [∇]	561 (21.96; 0.84; 0.77-0.93) [∇]	13 (26.53; 1.08; 0.57-2.04)
Sep.-Nov.	1,745,546	3396 (24.78; 0.99; 0.95-1.03)	610 (23.87; 0.94; 0.86-1.03)	18 (36.73; 1.74; 0.97-3.11)
Total		13,706 (100;;)	2,555 (100;;)	49 (100;;)

*: Based on the population size of the year 2014 (middle year), [∇]: Exposure is significantly lower than that in the rest of the year, ^Δ: Exposure is significantly higher than that in the rest of the year

Table 3: Comparison of numbers of animal bites and positive bites over gender of the victims

Gender	Population*	Total bites (%; OR; CI95%)	Positive bites (%; OR; CI95%)
Male	863,190	9685 (70.66; 2.48; 2.39-2.57) ^Δ	1781 (69.71; 2.36; 2.16-2.56) ^Δ
Female	882,359	4021 (29.34; 0.4; 0.39-0.42) [∇]	774 (30.29; 0.42; 0.39-0.46) [∇]
Total	1,745,549	13,706	2,555

*: Population size of the middle year (2014), [∇]: Exposure is significantly lower than that in the other group

^Δ: Exposure is significantly higher than that in the other group

CONCLUSIONS

Up to our knowledge, this is the first effort to understand the spatial-temporal dynamics of the rabies and underlying factors in Dhamar governorate. Rabies is still an endemic disease in Dhamar governorate. Exposure to bites/rabies varies according to several factors. The incidence of rabies in some rural areas was higher than urban areas.

Factors affecting differences in exposure between eastern and western parts need to be studied, including the size of the dog population and the presence/behaviors of the wildlife reservoir(s). The incidence of rabies in domestic animals, like bovine and equine species, and their roles in transmission of the disease also need to be studied. There is a need to enhance surveillance, diagnosis, and public

awareness of the disease. Additionally, management and vaccination of the dog population are also required for the control of rabies.

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التوزيع المكاني والزمني وبعض العوامل المرتبطة بداء الكلب في محافظة ذمار، اليمن: دراسة استرجاعية 2011-2017

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الملخص

داء الكلب مرض حيواني المنشأ قاتل للثدييات، بما في ذلك البشر، ولا يزال يمثل مشكلة صحية عامة متوطنة في العديد من البلدان الآسيوية والأفريقية، بما في ذلك اليمن. هدفت هذه الدراسة إلى وصف التوزيع المكاني والزمني وعوامل الخطورة المرتبطة بداء الكلب في محافظة ذمار، الجمهورية اليمنية. أُستمدت البيانات الخاصة بحالات داء الكلب المبلغ عنها للأعوام من 2011 إلى 2017 من البرنامج الوطني لمكافحة داء الكلب - وحدة محافظة ذمار، وحُللت ثلاثة مؤشرات لداء الكلب هي إجمالي العضات، والعضات الإيجابية، وعدد الوفيات. كما قُيم ارتباط مؤشرات داء الكلب بسنة الإبلاغ، والشهر/الموسم، والمنطقة، بالإضافة إلى عمر وجنس الضحايا. تم الإبلاغ عن إجمالي 13706 عضبة، و2555 عضبة إيجابية، و49 حالة وفاة بسبب داء الكلب في محافظة ذمار بين عامي 2011 و2017. كما بلغ متوسط الحدوث السنوي 111.64 عضبة، و20.80 عضبة إيجابية، و0.402 حالة وفاة لكل 100000 فرد. وقد كان الحدوث السنوي في بعض المناطق الريفية مرتفعاً و مماثلاً لذلك المسجل في المناطق الحضرية، فيما كان الحدوث في المناطق الشرقية أعلى بكثير عن ذلك المسجل في المناطق الغربية للمحافظة. و اظهر تحليل البيانات ان التعرض يزداد في فصل الشتاء (ديسمبر - فبراير) وينخفض في الصيف (يونيو - أغسطس). كما كان التعرض أعلى بكثير في الذكور ($OR \geq 2.36$) وفي الفئة العمرية 5-14 سنة ($OR \geq 2.42$) مقارنة بالإناث والفئات العمرية الأخرى، على التوالي. خلصت الدراسة الى ان داء الكلب لا يزال مرضاً متوطناً في محافظة ذمار، وهناك العديد من العوامل المؤثرة على احتمالية التعرض له. ولا زالت هناك حاجة إلى القيام بالعديد من الدراسات حول العوامل المرتبطة بارتفاع التعرض له في بعض المناطق، ولا سيما توافر النواقل والخوازن البرية المحلية وتوزيعها وطبيعتها تحركها. كما ان هناك حاجة أكبر لدراسة معدلات الإصابة بداء الكلب في الحيوانات الحقلية كالأبقار وفصيلة الخيليات ودورها في نقل المرض.

كلمات المفتاحية: التعرض، داء الكلب، التوزيع المكاني والزمني، ذمار، اليمن، معدل الوقوع

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تأثير القلي العميق وكمية البطاطس على بعض خصائص زيت القلي

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الكلمات

المفتاحية:

القلي

العميق

دورات

القلي قلي

البطاطس

الأحماض

الدهنية

الحرّة.

تاريخ

الاستلام

15 نوفمبر

2023

تاريخ

القبول

31 ديسمبر

2023

الملخص

هدفت هذه الدراسة لتقييم تأثير القلي العميق وعدد دورات القلي وكمية البطاطس في بعض خصائص زيت القلي، وبتطبيق نظامي نسب إضافة البطاطس والزيت وهما: (A1) نسبة الزيت 1:6 البطاطس و (A2) نسبة الزيت 1:3 البطاطس (وزن/ وزن)، كما دُرِس تأثير عدد دورات القلي (B) والتداخلات بينها على خصائص زيت القلي. أوضحت النتائج المتحصل عليها عدم وجود تأثير معنوي لنسب إضافة الزيت والبطاطس في كلاً من المحتوى الرطوبي ونسبة الأحماض الدهنية الحرة (FFA%) وقيمة الرقم اليودي (IV)، بينما كان لعدد دورات القلي والتداخلات بين نسب إضافة الزيت والبطاطس وعدد دورات القلي تأثيراً معنوياً ($P < 0.05$) عليها، حيث ارتفع المحتوى الرطوبي لزيت القلي ارتفاعاً معنوياً مع زيادة عدد دورات القلي من (0.041 ± 0.040) كمتوسط قبل القلي إلى (0.04 ± 0.495) بعد القلي، كما ارتفعت نسبة الاحماض الدهنية الحرة (FFA%) بشكل معنوي ($P < 0.05$) وبعلاقة خطية طردية مع زيادة عدد دورات القلي، ولوحظ أن قيمة محتوى الأحماض الدهنية الحرة في آخر قلية مازالت تعتبر مقبولة حسب شروط المواصفات لزيت الطعام لأغراض القلي والتحمير، كما لوحظ انخفاض قيمة الرقم اليودي (IV) بزيادة عدد دورات القلي، حيث كانت أقل قيمة في المعاملة (A1B7) حيث بلغت (0.054 ± 56.27) ملليجرام يود/100 جرام زيت، وكان لنسبتي إضافة البطاطس والزيت وعدد دورات القلي والتداخل بينهما تأثيراً معنوياً في قيمة رقم البيروكسيد (PV)، حيث ارتفع رقم البيروكسيد في الزيت معنوياً بزيادة عدد دورات القلي، وكانت أعلى قيمة في القلية السابعة (B7) حيث بلغت (0.20 ± 9.54) مليمكافئ اوكسيجين/ كجم زيت.

Effect of deep frying and quantity of potatoes in some frying oil characteristics

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Keyword

Deep

Frying

Palm

ABSTRACT

This study aimed to determine the impact of deep frying process, number of frying cycles per batch (B treatment) and potato to oil percentage as prepared from 6 : 1 (A1 treatment) and 3 : 1 (A2 treatment) ratio adds (w:w) (RDPO: potato fingers), on some frying oil characteristics. Results obtained from this study showed that the adds- ratio of oil and potatoes had no significant effect

Oil	on moisture content, free fatty acids content and iodine value of the refined deodorized palm olein (RDPO) frying oil. The results also showed that the moisture content and free fatty acids content of frying oil were increase in directly proportional to the number of frying cycles. The moisture content was increased significantly from (0.040 ± 0.041) before frying and reached to (0.495 ± 0.04) % after frying. The free fatty acids content of frying oil was increased with increasing frying cycles, but did not exceed the acceptable standards limits, whereas a decreases in iodine value of the frying oil were noted as the number of the frying cycles increases. The lowest iodine value was found in the oil of frying set A1B7, which it reached (56.27 ± 0.054 mg /100g Oil). Both adds-ratios and the number of frying cycles as well as the interaction between them had a significant effect on peroxide value of frying oil. The highest peroxide value was found in the oil after the frying cycle B7, where it reached (9.54 ±0.20) meqO ₂ /kg oil.
Potato	
Frying	
repeat	
frying	

المقدمة

المركبات تكون على هيئة مركبات متطايرة أو غير متطايرة (Chang et al., 1978).

وقد أشار Saguy and Dina, (2001) إلى بعض التغيرات النوعية التي تحدث خلال عملية التسخين للزيوت والتي يمكن أن يتم شرحها أو التعرف عليها عن طريق الفحص النظري والتي تكون واضحة عند تدهور زيوت القلي، ومن الأمثلة على ذلك، الأبخرة الناتجة من الزيت بكثافة أثناء التسخين، اسوداد أو عتامة الزيت وظهور زيادة في الرغوة عند القلي، إلى جانب إرتفاع لزوجة الزيت وظهور رائحة غير مستحبة والتي توصف بإحتراق الزيت Burnt، وهذه العلامات تسبب تغيرات في الخواص الفيزيائية والكيميائية للزيت والتي تعزى إلى ثلاثة تفاعلات رئيسية هي الأكسدة Oxidation و التحلل Hydrolysis والتكسر الحراري Thermal degradation.

لما سبق هدف هذا البحث إلى دراسة تأثير عملية القلي العميق وعدد دورات القلي ونسبة الزيت إلى البطاطس والتداخلات بينها في بعض خواص زيت أولين النخيل.

مواد وطرائق العمل Materials & Methods

استخدم في هذه الدراسة بطاطس صنف بركا Baraka Potatoes، حيث تم الحصول عليها من السوق المحلية، بينما تم الحصول على الزيت المستخدم في القلي وهو زيت أولين النخيل المكرر والمزال ال رائحة Refined Deodorized Palm Olein (RDPO) من الشركة اليمنية لصناعة السمن والصابون (YCGSI)، تعز، الجمهورية اليمنية وهو ماليزي المصدر حديث الإنتاج.

إعداد البطاطس وإجراء عملية القلي

جُهزت البطاطس بغسل الدرنات وإزالة الأتربة والأوساخ من السطح الخارجي لها، وقُشرت الدرنات بمقشرة يدوية لإزالة القشرة الخارجية وفقاً لـ (CheMan et al., 2010)، ثم قُطعت أطراف الدرنات طولياً بواسطة سكين يدوية بحيث يكون طول درنات البطاطس (7.5 سم ± 0.5 سم) وفقاً لطريقة (Karapantsios et al., 2010) وقُطعت الدرنات عرضياً بآلة تقطيع ميكانيكية إلى أصابع بعرض وسماكة (1 سم)

بعد القلي واحدة من أقدم الطرق التي عرفها البشر. في إعداد و تحضير و تجهيز الاغذية (Ahmad et al., 2009)، و عرّف (Ratti et al., 2003) القلي العميق بأنه عملية تستخدم لطبخ الأغذية بغمرها بالزيت أو الدهن الصالح للأكل والإبقاء على الغذاء على درجة حرارة بين (160- 200 م) لفترة من الزمن تكون كفيلاً بإكساب الغذاء المذاق والنكهة واللون المميز للأغذية المقلية، و ذكر (Ismail, 2005) أنه منذ أوائل الثمانينات من القرن الماضي وزيت أولين النخيل يتم استهلاكه بشكل متزايد في أغراض القلي حيث تستهلك ملايين الأطنان من زيت أولين النخيل لأغراض القلي في العالم إما محلياً في المنازل والمطاعم أو تجارياً في المصانع وشركات الأغذية وذلك بسبب المزايا الطبيعية والاقتصادية التي تجعله مفضل على غيره من الزيوت النباتية والدهون الأخرى.

أن القلي الدهني العميق على درجات حرارة عالية بين (160-20 م)، ووجود الهواء والرطوبة يعملان على تدهور خواص الزيوت والدهون ويغيران بعض صفاته الطبيعية والكيميائية والتي ستؤثر على خواص القلي وثبات فترة الخزن للمنتجات المقلية (Razali et al., 1999).

حيث ذكر القليوي ومصطفى، (2005) أن جودة وثباتية الزيوت المستخدمة في القلي تعد من الأمور التي يهتم بها العاملون في مجال تكنولوجيا الأغذية نظراً للتغيرات التي تحدث أثناء عملية القلي وأهمها الأكسدة الحرارية وتكوين المركبات غير المستقرة مثل البيروكسيدات والتي سرعان ما تتحول إلى هيدروبيروكسيدات وتتحلل إلى الألدهيدات وتكوينات وكذلك تتكون Polymerization، وتنفرد الاحماض الدهنية الحرة FFA، وتتكون نكهات غير مرغوبة Off flavor، وتتكون الرغوة Foam formation وتزيد اللزوجة Viscosity-increases.

يؤدي تسخين الزيوت والشحوم إلى سلسلة من التحلل للجليسيريدات الثلاثية والتي تتضمن التحلل إلى أحماض دهنية حرة ب صورة Fatty acyl peroxides بالإضافة إلى جذور حرة Free radicals من نواتج تفاعلات الأكسدة، وفي نهاية المطاف تتكون من جليسيريدات ثلاثية عديدة وثنائية التبلمر، وكذلك نواتج بأوزان جزيئية منخفضة، وهذه

اجريت بعض الفحوصات على عينات الزيت بعد القلي شملت الاتي: تقدير نسبة الأحماض الدهنية الحرة في Fatty Acids، تقدير نسبة الاحماض الدهنية الحرة في الزيت وفقاً لطريقة (1997)، AOCS، تم تقدير رقم البيروكسيد Peroxide Value ، تم تقدير رقم البيروكسيد للزيت وفقاً لطريقة (1997)، AOCS. وتقدير الرقم اليودي: Iodine Value، تم تقدير الرقم اليودي وفقاً لطريقة AOCS، (2009).

تم تقدير المحتوى الرطوبي للزيت وفقاً لطريقة (2009) AOCS، باستخدام جهاز Moisture Analyzer رقم الموديل Model Type: Hg63-P: من إنتاج الشركة السويسرية: Switzerland -Mettler Toledo .

التحليل الإحصائي

حُللت النتائج باستخدام التصميم العشوائي الكامل Completely Randomized Design (C.R.D) للتجارب العاملية (Factorial Experiments) لثلاثة مكررات باستخدام البرنامج الإحصائي SAS-2006 (Statistical Analysis System) بواسطة اختبار تحليل التباين ثنائي الاتجاه (Anova Two Way) وتمت المقارنة بين متوسطات القراءات بتطبيق اختبار أقل فرق معنوي (LSD) عند مستوى معوية (5 % Significant Level).

النتائج والمناقشة Results & Discussion

مؤشرات الجودة لزيت أولين النخيل قبل الاستخدام في عملية القلي (RBDP)

يوضح الجدول (1) نتائج خواص جودة الزيت المستخدم والتي شملت نسبة الاحماض الدهنية الحرة ورقم البيروكسيد والرقم اليودي ونسبة الرطوبة حيث كانت في الزيت (0.068) و (0.01±) و (0.02± 0.296) و (0.20±56.857) و (0.035) و (0.01±) على التوالي.

Warner and knowlton, (0.2± سم) وفقاً لطريقة (1997)، ثم غُسلت بتيار مائي لإزالة آثار النشاء والمواد الأخرى الموجودة على السطح الخارجي لأصابع البطاطس بعد التقطيع كما ذكر (Pyle and Boucnox, 2004)، ثم وضعت في ماء بدرجة حرارة الغرفة منعاً من حدوث عملية اسمرار إنزيمي لأصابع البطاطس وتغير لونها وفقاً لما ذكره (Farhoosh and Moosavi, 2009)، ومن ثم جُففت أصابع البطاطس بقماش الململ لإزالة آثار الماء الموجود على السطح الخارجي لأصابع البطاطس وفقاً ل (Pyle et al., 2003)، وأهملت القشرة وحواف الدرناات لأنها غير منتظمة. عُمِلت سلسلة من التجارب قبل البدء بالبحث وعلى ضوءها تم ضبط المعايير الأساسية وثبتت أثناء الدراسة حيث حُددت كمية امتصاص البطاطس المقلية من الزيت في القلية الواحدة وزناً، وحُددت كمية الزيت المطلوب إضافته في بداية كل مرحلة وحُدّد زمن القلي وفقاً لطريقة (Ismail et al., 2008). كما تمت عملية القلي بتطبيق نظامي نسب إضافة البطاطس والزيت وهما:- المعاملة A1: نسبة الزيت 1:6 البطاطس (وزن / وزن)، المعاملة A2: نسبة الزيت 1:3 البطاطس (وزن / وزن)، وفقاً لطريقة (Karapantsios et al., 2009)، ولعدد سبع قليات للنظامين بنظام القلي المتقطع (على دفعات) وفقاً لطريقة (Ramadan et al., 2006)، حيث تم وضع الزيت في القلاية بكمية (3 كيلوجرام ±5 جرام) للزيت وأخذ الوزن لهما، وُفِع درجة حرارة الزيت إلى (180 م) وفقاً لطريقة (CheMan et al., 2010)، وأضيف أصابع البطاطس إلى القلاية بحيث تكون النسبة (زيت : 6 : 1 بطاطس) ذلك بوزن (500 جرام بطاطس ± 2.5 جرام)، وأضيفت أصابع البطاطس إلى القلاية لتكون النسبة (زيت : 3 : 1 بطاطس) بوزن (1000 جرام بطاطس ±5 جرام)، وتمت عملية القلي لمدة (14 ± 1 دقيقة) وفقاً لGuardiola et al., (2007) باستخدام جهاز القلي بالطريقة المكشوفة وفقاً ل (Tsaknis et al., 2005).

فحوصات تقييم خصائص زيت القلي

الجدول 1. مؤشرات الجودة لعينة زيت أولين النخيل قبل القلي

م	الفحص	النتيجة	م. ق. ي. 1754 / 2012 م
1	نسبة الأحماض الدهنية الحرة %	0.01± 0.068	5 كحد أقصى
2	رقم البيروكسيد (مليمكاف / أكسجين / كيلو جرام زيت)	0.02±0.296	15 كحد أقصى
3	الرقم اليودي (مليجرام يود / 100 جرام زيت)	0.20± 56.857	56 ≤
4	نسبة الرطوبة	0.01± 0.035	0.2% كحد أقصى

الجدول 2. تأثير نسبة إضافة البطاطس ودورات القلي في المحتوى الرطوبي لزيت القلي

LSD% B	متوسط A	B7	B6	B5	B4	B3	B2	B1	B0	دورات القلي
										نسبة اضافة البطاطس
0.079	0.579 0.06±	0.630 0.11±	0.767 0.063±	0.937 0.093±	0.497 0.043±	0.653 0.017±	0.757 0.063±	0.357 0.023±	0.034 0.07±	A1
	0.553 0.053±	0.593 0.067±	0.580 0.04±	0.740 0.07±	0.667 0.063±	0.507 0.083±	0.660 0.03±	0.633 0.057±	0.046 0.013±	A2
LSD,5% AB = 0.112		0.612 0.089±	0.673 0.052±	0.838 0.082±	0.582 0.053±	0.580 0.059±	0.708 0.047±	0.495 0.04±	0.040 0.041±	متوسط B
0.0395										LSD% A

الجدول 3. تأثير نسبة إضافة البطاطس ودورات القلي في محتوى الأحماض الدهنية الحرة لزيت القلي

LSD% B	متوسط A	B7	B6	B5	B4	B3	B2	B1	B0	دورات القلي
										نسبة إضافة البطاطس
0.003	0.094 0.0027±	0.115 0.0037±	0.110 0.0016±	0.111 0.0043±	0.093 0.0013±	0.085 0.0022±	0.085 0.0026±	0.085 0.0052±	0.076 0.0002±	A1
	0.095 0.0011±	0.111 0.0004±	0.103 0.0033±	0.100 0.0013±	0.098 0.0014±	0.096 0.0004±	0.090 0.0005±	0.084 0.0004±	0.079 0.0009±	A2
LSD,5% AB = 0.005		0.113 0.0021±	0.107 0.0025±	0.105 0.0028±	0.095 0.0013±	0.090 0.0013±	0.087 0.0016±	0.084 0.0028±	0.077 0.0005±	متوسط B
0.002										LSD% A

الجدول 4. تأثير نسبة إضافة البطاطس ودورات القلي في قيمة الرقم البيودي لزيت القلي

LSD% B	متوسط A	B7	B6	B5	B4	B3	B2	B1	B0	دورات القلي
										نسبة إضافة البطاطس
0.37	56.53 0.128±	56.27 0.054±	56.71 0.003±	56.36 0.323±	56.81 0.013±	56.38 0.153±	56.50 0.284±	56.33 0.187±	56.86 0.003±	A1
	56.55 0.275±	56.67 0.158±	56.39 0.284±	56.43 0.120±	56.32 0.439±	56.86 0.156±	56.41 0.272±	56.44 0.212±	56.86 0.558±	A2
LSD,5% AB = 0.52		56.47 0.106±	56.55 0.144±	56.39 0.222±	56.57 0.226±	56.62 0.155±	56.46 0.278±	56.39 0.200±	56.86 0.281±	متوسط B
0.19										LSD% A

الجدول 5. تأثير نسبة إضافة البطاطس ودورات القلي في رقم البيروكسيد لزيت القلي

LSD% B	متوسط A	B7	B6	B5	B4	B3	B2	B1	B0	دورات القلي
										نسبة إضافة البطاطس
0.27	5.59 0.16 ±	9.62 0.04±	9.26 0.32±	7.99 0.32±	4.90 0.07±	4.42 0.14±	4.15 0.23±	2.30 0.13±	2.09 0.001±	A1
	6.88 0.13±	9.45 0.35±	8.81 0.13±	8.53 0.06±	8.13 0.01±	6.62 0.02±	6.43 0.15±	4.65 0.09±	2.44 0.26±	A2
LSD,5% AB = 0.39		9.54 0.20±	9.04 0.23±	8.26 0.19±	6.52 0.04±	5.52 0.08±	5.29 0.19±	3.47 0.11±	2.27 0.13±	متوسط B
0.14										LSD% A

تأثير نسبة إضافة البطاطس ودورات القلي في المحتوى الرطوبي لزيت القلي

تشير النتائج في الجدول (2) إلى أنه لا يوجد تأثير معنوي لنسب إضافة البطاطس والزيت في المحتوى الرطوبي لزيت القلي ولا توجد فروق معنوية بين نسب الإضافة للبطاطس والزيت A1 و A2 (1:6 و 1:3) والمتوسط العام لهما (0.579 و 0.06± و 0.053± 0.553) على التوالي.

وتشير هذه القيم إلى مطابقة عينة الزيت المستخدمة لشروط المواصفات القياسية اليمنية (م. ق. ي 1754/2012) الخاصة بزيت الطعام لأغراض القلي والتحمير، حيث تمت الإشارة إلى الأحماض الدهنية الحرة برقم الحمض وحددت الحد الأعلى بـ 10، وتمت القسمة على 1.99 للتحويل إلى نسبة أحماض دهنية حرة 5 كحد أقصى (الفقيه، 2012).

الأولى إلى (0.12 ± 0.96) ، وأوضحت نتائج التداخل بين نسبي إضافة البطاطس والزيت مع عدد دورات القلي إلى وجود تأثيراً معنوياً في محتوى الأحماض الدهنية الحرة لزيت القلي، وكانت أقل قيمة لمحتوى الأحماض الدهنية الحرة في المعاملة A2B1 (0.0004 ± 0.084) ، وكانت أعلى قيمة لمحتوى الأحماض الدهنية الحرة في المعاملة A1B7 (0.115 ± 0.0037) ، وقيمة محتوى الأحماض الدهنية الحرة في آخر قلية مازالت تعتبر مقبولة حسب المواصفات القياسية اليمينية (م. ق. ي 2012/1754) لزيت الطعام لأغراض القلي والتحمير (5 كحد أقصى)، و تتفق هذه النتائج مع نتائج دراسة Ramadan et al., (2006) الذين أثبتوا في نتائجهم أن محتوى الأحماض الدهنية الحرة ارتفعت في زيت أولين النخيل وزيت دوار الشمس وزيت بذرة القطن من 0.069 و 0.050 و 0.052 قبل القلي إلى 0.24 و 0.19 و 0.34 بعد القلي على التوالي، وهذه القيم تعتبر أقل من 0.5 وهي القيمة التي يجب نبد الزيت المستخدم للقلي عند الوصول لها، والزيادة لا تكون هامة عموماً بين مختلف الزيوت .

نتيجة لحدوث التميؤ للزيت المستخدم في القلي تتشكل الأحماض الدهنية الحرة بسبب حدوث تحلل hydrolytic للزيت (Gertz, 2002).

تأثير نسبة إضافة البطاطس ودورات القلي في قيمة الرقم اليودي لزيت القلي:

أن التغير في قيمة الرقم اليودي يكون مرتبطاً بشكل رئيسي بدرجة عدم التشبع ويتناقص بشكل مستمر عند أكسدة الزيوت نتيجة عملية القلي (أكسدة حرارية)، وكلما تواجدت الأحماض الدهنية عديدة عدم التشبع في زيت القلي كلما مال الزيت بشكل أسرع لأن يتأكسد عند القلي الدهني العميق، وتقل عملية التأكسد للزيت في وجود مضادات الأكسدة سواءً الطبيعية أو الصناعية، وأشارت نتائج الدراسة التي قاموا بها أن وجود مضادات الأكسدة عملت على تقليل الانخفاض في الرقم اليودي لزيت القلي وعملت كذلك في تقليل تدهور زيت القلي، وكان الزيت أكثر استقراراً عند القلي (CheMan et al., 2010).

تُظهر النتائج المتحصل عليها في الجدول (4) عدم وجود تأثير معنوي لنسبي إضافة البطاطس والزيت في قيمة الرقم اليودي لزيت القلي إذ لا يوجد فروق معنوية بين نسبي الإضافة للبطاطس والزيت (A1 و A2) و قد كان المتوسط العام لهما 56.53 ± 0.128 و 56.55 ± 0.275 مليجرام يود/ 100 جرام زيت على التوالي، وبالنظر للنتائج في الجدول (4) يتبين وجود تأثير لعدد دورات القلي في قيمة الرقم اليودي لزيت القلي حيث انخفضت قيمة الرقم اليودي بعد القلي مقارنة بما كان عليه قبلة، من (56.86 ± 0.281) قبل القلي لتصل إلى (56.39 ± 0.222) مليجرام يود/ 100 جرام زيت في القلية الخامسة كما ظهرت فروق في بعض دورات القلي، وهذا يتفق مع النتائج التي حصل عليها (CheMan et al., 1999) حيث أظهرت النتائج انخفاض قيمة الرقم اليودي لزيت أولين النخيل أثناء عملية القلي من (56.07 ± 0.35) قبل القلي إلى (52.02 ± 0.35) مليجرام يود/ 100 جرام زيت بعد القلي، وتتفق النتائج أيضاً مع نتائج Rehman et al., (2006) الذين وجدوا أن قيمة الرقم اليودي لزيت دوار

كما توضح النتائج المتحصل عليها في الجدول (2) أن لعدد دورات القلي تأثير معنوي في المحتوى الرطوبي لزيت القلي حيث ارتفع المحتوى الرطوبي لزيت القلي ارتفاعاً معنوياً مع زيادة عدد مرات القلي كما وجدت فروق معنوية بين معظم القليات فيما بينها وتعتبر القلية الأولى هي الأفضل من حيث انخفاض المحتوى الرطوبي لزيت القلي فيها مقارنة مع بقية القليات حيث ارتفع متوسط المحتوى الرطوبي من $(0.040 \pm 0.041\%)$ للزيت قبل القلي إلى $(0.612 \pm 0.089\%)$ بعد القلي، كما أشارت نتائج التداخل بين نسب إضافة البطاطس والزيت مع عدد القليات إلى وجود فروق معنوية بين القليات فيما بينها حيث كانت أقل قيمة للمحتوى الرطوبي لزيت القلي بين القليات في المعاملة A1B1 $(0.357 \pm 0.023\%)$ وكانت أعلى قيمة للرطوبة الزيت بين القليات في المعاملة A1B5 $(0.937 \pm 0.093\%)$.

ويرجع سبب ارتفاع نسبة الرطوبة في الزيت الى خروج الرطوبة في نظام القلي العميق من البطاطس المغمورة في الزيت الساخن وهذه الرطوبة المكتسبة تسبب العديد من التفاعلات التي تزيد من تدهور الزيت (Hassan et al., 2005).

تأثير نسبة إضافة البطاطس ودورات القلي في نسبة الأحماض الدهنية الحرة لزيت القلي

ترجع اسباب الزيادة في نسبة الحموضة والأحماض الدهنية الحرة إلى التميؤ والأكسدة لزيت القلي، حيث تنتج الأحماض الدهنية الحرة أثناء تدهور زيت القلي نتيجة لتأثير درجة الحرارة العالية (Ahmad et al., 2009).

تظهر النتائج المتحصل عليها في الجدول (3) إلى أنه لا يوجد لنسبي إضافة البطاطس والزيت تأثيراً معنوياً في محتوى الأحماض الدهنية الحرة لزيت القلي ولا يوجد فروق معنوية بين نسبي الإضافة للبطاطس والزيت (A1 و A2) والمتوسط العام لهما (0.0027 ± 0.094) و (0.0011 ± 0.095) على التوالي، وبالنظر إلى النتائج المتحصل عليها والموضحة في الجدول (3) نجد أن لعدد القليات تأثيراً معنوياً ($P < 0.05$) في محتوى الأحماض الدهنية الحرة لزيت القلي حيث ارتفع محتوى الأحماض الدهنية الحرة ارتفاعاً معنوياً بعلاقة خطية طردية مع زيادة عدد مرات القلي ولوحظ وجود فروق معنوية بين معظم القليات فيما بينها وارتفع محتوى الأحماض الدهنية الحرة من (0.0005 ± 0.077) كم متوسط لمحتوى الأحماض الدهنية الحرة قبل القلي إلى (0.113 ± 0.0021) بعد القلي، وهذه النتائج تتفق مع نتائج Xu et al., (1999) الذين ربطوا زيادة محتوى الأحماض الدهنية الحرة بساعات القلي وزيادة عدد القليات حيث وجدوا ان الأحماض ترتفع بسرعة في القليات الأولى، ثم بشكل متزايد بعد ذلك، فقد ارتفع محتوى الأحماض الدهنية الحرة في زيت أولين النخيل من (0.93) قبل القلي إلى (2.4) نهاية عملية القلي، و تتفق كذلك مع النتائج التي حصل عليها (Ismail, 2005) إذ زادت قيمة محتوى الأحماض الدهنية الحرة لزيت أولين النخيل من (0.04) قبل القلي إلى (0.21) في وسط القلي ثم زادت نهاية عملية القلي لتصل إلى (0.24) ، كما تتفق أيضاً مع نتائج Wai, (2007) حيث ارتفعت محتوى الأحماض الدهنية الحرة في زيت القلي من (0.22) في القليات

في آخر القلي، كما تتفق مع ما توصل إليه (Jaswir et al., 2000) حيث زاد رقم البيروكسيد الزيت أثناء قلي البطاطس من (0.91 إلى 11.70)، وتتفق مع نتائج (Nasirullah, 2005) والذي ذكر أن قيمة رقم البيروكسيد لزيت فول الصويا وزيت نخالة الرز زادت من (3.6) إلى (6.0) و من (5.7) إلى (11.2) أثناء القلي على التوالي، كذلك مع نتائج (Goburdhun et al., 2000) الذين أوضحوا أن رقم البيروكسيد زاد عند قلي رقائق البطاطس من (6.6 إلى 12.6) مليمكاف/كجم زيت، كما تتفق مع ما حصل عليه Ringkasan, (1982) حيث ذكر أن رقم البيروكسيد زاد في زيت أولين النخيل RBD والمضاف له مضاد أكسدة وبدون إضافة عند قلي شرائح الموز من (1.1) قبل القلي إلى (4.7) في الزيت غير المضاف له مضاد أكسدة و إلى (2.0) في الزيت المضاف له مضاد أكسدة.

الاستنتاجات: Conclusions

استخدام نسبة إضافة البطاطس والزيت A1 (الزيت 6 : 1البطاطس) (w/w) في القلي العميق للبطاطس باستخدام زيت أولين النخيل كانت افضل و بشكل ملحوظ على استخدام نسبة إضافة البطاطس و الزيت A2 (الزيت 3 : 1البطاطس) (w/w) في جميع الصفات المدروسة لزيت القلي (محتوى الأحماض الدهنية، قيمة رقم البيروكسيد، قيمة الرقم البودي، الرطوبة الموجودة في الزيت بعد القلي)، كما أن إجراء عدد سبع دورات قلي متقطعة بزيت القلي وبدون إضافة زيت جديد لزيت القلي مقبول ومناسب جداً، كما أظهرت نتائج التحليل الكيميائي للزيت بعد القلية السابعة مطابقته للاشتراطات القياسية اليمينية وأن الزيت مازال صالح للاستخدام الغذائي، وكان لتداخل نسبي إضافة الزيت وأصابع البطاطس مع عدد دورات القلي تأثيراً معنوياً واضحاً في جميع الصفات التي المدروسة، ولوحظ أنه بزيادة نسبة الزيت إلى البطاطس يقل التأثير على خصائص البطاطس المقلية. وأظهرت نتائج التحليل الإحصائي تفوق نسبة الإضافة (A1) على نسبة الإضافة (A2)، وعلية في حال الرغبة في زيادة عمر الزيت لإجراء عدد قلايات أكثر ينصح بزيادة كمية الزيت.

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الشمس إنخفضت بعد القلي للبطاطس وأغذية أخرى فيه نتيجة تأكسد الزيت حيث تشير النتائج أنه بزيادة عدد القلي ازداد الانخفاض في الرقم البودي بشكل ملحوظ من (127.50 \pm 1.94) إلى (63.75 \pm 1.94) جرام زيت بين المرات المختلفة من القلي، بينما نسب (Cuesta et al., 1991) النقص في قيمة الرقم البودي إلى تكسر الروابط الثنائية بالأكسدة و polymerization أثناء القلي، وكما كان الزيت قليل عدم التشبع كلما كان الانخفاض أقل، أما بالنسبة للتداخل بين نسبي إضافة البطاطس والزيت متعدد القليات فقد لوحظ وجود فروق معنوية في بعض التداخلات وكانت أعلى قيمة للرقم البودي في المعاملة A2B3 ($0.156 \pm$ 56.87) وأقل قيمة للرقم البودي في المعاملة A1B7 ($0.064 \pm$ 56.27) مليجرام يود/100 جرام زيت، وتتفق النتائج مع النتائج التي حصل عليها Tyagi and Vasishita (1996) والذي قيم أداء زيت فول الصويا حيث انخفض قيمة الرقم البودي من 129.8 إلى 96.2، وزيت فول الصويا المهدرج جزئياً انخفض من 74 إلى 60.2 مليجرام يود/100 جرام زيت.

تأثير نسبة إضافة البطاطس ودورات القلي في قيمة رقم البيروكسيد لزيت القلي:

يستخدم رقم البيروكسيد في متابعة التغيرات التي تحدث للأحماض الدهنية غير المشبعة الموجودة في الزيت والتغيرات التي تحصل للزيوت نتيجة الأكسدة الحرارية وتشكل البوليمرات في الزيت (دهان، 1992).

تبين النتائج في الجدول (5) وجود تأثيراً معنوياً لنسبي إضافة البطاطس والزيت في رقم البيروكسيد وظهرت فروق معنوية بين نسبي الإضافة A1 و A2 وكانت في المتوسط العام لرقم البيروكسيد ($0.16 \pm$ 5.59 و $0.13 \pm$ 6.88) مليمكاف/كجم زيت على التوالي، كما يتضح من الجدول (5) وجود تأثيراً معنوياً لعدد القليات في رقم البيروكسيد حيث ارتفعت قيمة رقم البيروكسيد معنوية بعلاقة خطية مع عدد دورات القلي، وكانت أفضل قيمة لرقم البيروكسيد عند القلية الأولى B1 ($0.11 \pm$ 3.47) وأعلى قيمة عند القلية السابعة B7 ($0.20 \pm$ 9.54) مليمكاف/كجم زيت، وتتفق النتائج مع ما حصل عليه Wai, (2007) حيث ارتفعت قيمة رقم البيروكسيد في زيت القلي إلى (5) ثم (10) في القليات الأولية ثم ارتفع إلى (19.8) مليمكاف/كجم زيت في آخر القلي، و ذكر (Ghazali, 2007) أن رقم البيروكسيد يحدث له زيادة سريعة في أول مراحل القلي ومن ثم تكون الزيادة طفيفة في بقية مراحل القلي. أما بالنسبة للتفاعل بين نسبي إضافة البطاطس والزيت متعدد القليات فقد أثر تأثيراً معنوياً في رقم البيروكسيد، وكانت أعلى قيمة لرقم البيروكسيد في المعاملة A1B7 ($0.04 \pm$ 9.62) وأقل قيمة لرقم البيروكسيد في المعاملة A1B1 ($0.13 \pm$ 2.30) مليمكاف/كجم زيت، و هذه النتائج تتفق مع النتائج التي حصل عليها (CheManet al., 1999) إذ بينت نتائجهم ارتفاع رقم البيروكسيد لزيت أولين النخيل أثناء عملية القلي من (0.9) قبل القلي إلى (11.70) في آخر قلية، وتتفق كذلك مع نتائج الدراسة التي قام بها (Rehman et al., 2006) حيث زاد رقم البيروكسيد لزيت القلي بزيادة زمن القلي إذ ارتفع من ($0.06 \pm$ 3.06) قبل القلي إلى ($2.76 \pm$ 34.70)

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Original Article

Comparative Study for the physicochemical characteristics of Local and Imported Apple Fruits in Yemen

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ABSTRACT

This work aimed to estimate the physical and chemical properties of local apple cultivar (Anna variety) and three varieties of imported apple fruits include (Granny Smith, Red Delicious and Honeycrisp apples) to compare the quality parameters of local apple with imported apple fruits. The samples were collected from local markets in Dhamar city, Yemen. The results showed that the physical properties of apple fruits were, the whole fruit weight (122.04, 113.5, 117.68 and 102.94) g, the pulp weight (109.16, 98.59, 102.77 and 89.7) g, the peel weight (11.76, 11.62, 10.92 and 8.84)g and the seeds weight was (0.0, 0.31, 0.14 and 0.41) g, the fruit extract volume was (47.83, 52.50, 57.83 and 41.70) ml in local, Granny Smith, Red Delicious and Honeycrisp apple varieties respectively. The chemical properties of apples juice were as following ,the moisture (83.43, 82.93, 84.40 and 86.27) %, total solids (16.57, 17.07, 15.77 and 13.73) %, total soluble solids, TSS (13.82, 10.85, 12.15 and 11.68) °Brix, reducing sugars (8.32, 6.59, 8.69 and 8.84) %, pH (3.61, 3.69, 4.10 and 4.2), titratable acidity (TA) (0.53, 0.51, 0.22 and 0.22) %, while vitamin (C) content was (16.01, 15.72, 17.46 and 17.61 mg/100 ml) in local, Granny Smith, Red Delicious and Honeycrisp apple varieties respectively. The Maturity indexes were the TSS/TA ratio (26.92, 24.88, 55.39 and 54.58), starch-iodine index (7.67, 10, 10 and 10) and Thiault index (TI) (198.28, 164.32, 149.67 and 143.92) in local, Granny Smith, Red Delicious and Honeycrisp apple varieties respectively. The results of this research revealed that the local apple fruits have good quality indicators, in terms of its physical properties and high TSS content, but the high acidity and starch content may be the reasons of its low sweetness and negatively effects on their quality characteristics.

INTRODUCTION

Apple is the pomaceous fruit of the apple tree which belong to the rose family. The genetic variability found in the apple has allowed adapted types to be selected for different environments and regions (Abdualrahman, 2015). Apple fruits quality is an important factor in minimally processed or fresh-cut slices. The physicochemical properties of fruits are important for nutritional, economic, food quality after processing and storage stability considerations.

Fresh apples juices a source of various bioactive compounds include antioxidants as ascorbic acid, which give them a value addition in food commercialization. It's highly appreciated and consumed because of its flavor and nutritional

properties (Kanchan *et al.*, 2020). Apple fruits represent an important source of some antioxidant nutrients in western countries because the apples are the most consumed fruits in these countries. The antioxidants and ascorbic acid contents in apple fruits have been widely studied (Haytowitz *et al.*, 2009) and (Bodner-Montville *et al.*, 2006). Bongers *et al.*, (1994) studied the physicochemical properties of apple fruits and found significant differences in some quality parameters between apples from different origins. They also reported that the apples produced in United States, especially delicious had some superior quality parameters compared to the apple fruits from other origins.

The ecological conditions, cultural practices and genetic features are the most factors that affected on the phenology, morphology and biochemical contents of apple fruits (Geçer *et al.*, 2020). The pre-harvest treatments of apple trees effects on their fruit's physicochemical properties. El-Sabagh *et al.*, (2012) reported that the sprayed with Hydrogen Cyanamide (Dormex) increased significantly the average of fruit weight, fruit size, length, diameter, Total Soluble Solids (TSS) and TSS/acid ratio in compare to the control; however, they caused a significantly decreased in both fruit firmness and acidity).

Storage of apple fruits cultivars resulted in significant increase in weight loss, while starch score, juice content, acidity, TSS, total sugar, pH, ascorbic acid and TSS: TA ratio decreased with prolong storage period (Banoo *et al.*, 2018). Aly *et al.*, (2019) reported that the total sugar and TSS content was significantly increased with increasing storage periods of Anna apples, while ascorbic acid and acidity was significantly decreased during cold storage.

The firmness and starch iodine in apple fruits are decreased over the storage time since harvest, but the TSS content is increased. Climate changes effects on the texture and taste of apples due to it early flowering and high temperatures during the growing phase (Daniela and Vanessa, 2020). During the maturity progress of apple fruits, the physicochemical properties are change. For determination the maturity degree some tests are used. The starch pattern index (SPI) test is one of the tests that widely used to assess apple fruits maturity. It measures the changes in starch concentration in the fruits during maturation and ripening.

SPI values increased and starch concentration decreased with maturity progress of fruits. The binding capacity of iodine to starch depends on starch composition and by the amylose concentration. Amylose concentration in total starch decreases during maturity progress and reached to low levels at the later stages of fruits. The Starch index (SI) is less reliable in representing total starch during later stages of Fuji apple maturation (Doerflinger *et al.*, 2015 and Fan *et al.*, 1995). Thammawong and Arakawa, (2009) found that, the starch degradation in apples are varied depends on apples cultivars, and they suggested that, iodine staining is recommended more for determining the maturation of late-maturing cultivars rather than the early-maturing.

In Yemen, the apples fruits are cultivation in some areas like Sa'adah, Emran and Dhamar governorates. The local apple varieties are belonging

to the (Anna and Ein shemer) apple varieties. The imported apples had more consumers' acceptability than local apples in Yemen. Therefore, we conducted this research to study and compare the physiochemical properties of local and imported apples and define the reasons for the more acceptability of imported apples than local apples fruit.

MATERIALS AND METHODS

Sampling:

Apple fruits were collected randomly from local markets of Dhamar city during the period between August and November, 2022. The local apple variety was Anna variety while; an imported apple was Granny Smith, Honeycrisp and Red Delicious (Fig. 1). The fruits were placed in plastic bags and brought to the laboratory of Biotechnology and Food Technology Department, Faculty of Agriculture and Veterinary Medicine; Tamar University for analysis the physical and chemical properties of apple fruits and their extracted juice.

Physical properties of fruits

The total weight of fruit was measured using an analytical balance. The peel was removed from the fruits by knife carefully. Then, the fruits were cutting and the seeds were removed manually. After then, the fruits flesh, seeds and peel weight were measured. For juice extraction, the fruits pulp was crushed by electrical blender, the mixed, filtered through sieving, weight and volume measured.

Chemical analysis of apples juice

Apples` juice was obtained from fruits pulp. Fruits pulp was blended and sieved to remove the seeds. The extracted juice was used for chemical analysis including the following parameters: Moisture and total solids content, acidity, total soluble solids (TSS), reducing sugars, vitamin (C) and the pH value.

Determination of moisture and total solids content

Moisture content was estimated by drying method using microwave oven as described by (Suhaimi *et al.*, 2018). 10 g of apple juice were weighted in Petri dish and dried until the weight stable. The yield was cooled, weighted. The moisture content and total solids were calculated, five replicates were analysis and the average was calculated.

Determination of total soluble solids (TSS)

The total soluble solids (TSS) of apples pulp were determined using a hand refractometer, Atago Company, Japan.

Estimation of reducing sugars

Reducing sugars contents were estimated by Lane-Eynon method (AOAC, 1990). Juice sample (20 ml) was transfer to 500 ml volumetric flask. 100 ml water were added, and then the juice mixture/solution was neutralized with NaOH solution to phenolphthalein end point. 10 ml of neutral lead acetate solution was added to the flask contents. The flask contents was shaken and let stand for 10 min. Potassium oxalate solution in small amounts was added to the mixture in the flask until there is no further precipitation. The volume was completed with distilled water and mixed well. After that the sample mixture was filtered through Whatman No. 1 filter paper. 50 ml of filtrate was transferred to the burette. 5 ml each of Fehling A and B solutions was transferred to 250 ml conical flask. Fehling solution was titrated with sample solution from the burette with continuous heating to boiling and 3 drops of methylene blue indicator was added and continuation the titration until the indicator is decolorized and the brick red color was appeared. The consumed sample solution volume in titration was recorded. Duplicated titration was carried and the average of sample solution was calculated. The direct reducing sugar was calculated by the equation. The Fehling factor was primary found by using a known glucose solution concentration.

$$\text{Reducing sugar (\%)} = \frac{(\text{Fehling factor}) \times \text{Vol. made up} \times 100}{\text{Wt. of sample} \times 1000}$$

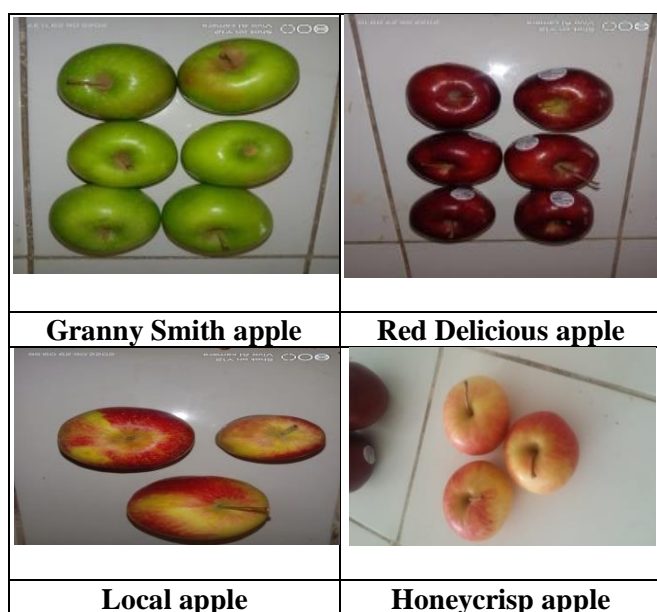
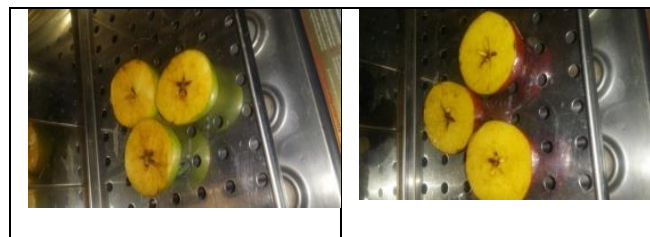


Fig. 1. Apple fruit varieties include in this study

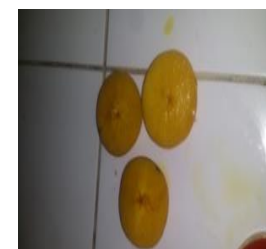


Granny Smith apple

Red Delicious apple



Local apple



Honeycrisp apple

Figure 2: Starch-iodine index of apples fruits.

Estimation of pH:

The pH was estimated using a pH meter from HANNA Company. During the measuring process, the electrode was immersed directly in the juice extract and reading was recorded.

Determination of titratable acidity (TA)

The titration method with sodium hydroxide NaOH (0.1 N) and phenolphthalein indicator was used for acidity measuring. The amount of alkali consumed in titration was recorded and the titratable acidity was calculated and expressed as malic acid (Kanchan *et al.*, 2020).

Determination of vitamin (C) content

Vitamin (C) was estimated by iodine titration method according to technique described by Ciancagliina *et al.* (2001). In brief, 20 ml of the apples fruit juice was transferred to 250 ml Erlenmeyer flask. 25 ml of distilled water were added. From the diluted sample, 10 ml were transferred to 250 ml beaker and 1 ml of cooled, filtered, starch added. Slow titration by potassium iodide with stirring was carried out to reach the end point and dark blue color appeared. The volume of potassium iodide used in titration was determined and the vitamin C content was calculated as follows:

$$\text{Vitamin C (mol/L)} = \frac{\text{ml of potassium iodide} \times \text{iodide molarity}}{\text{sample volume (ml)}}$$

The amount of vitamin C in (mg/100 ml) was calculated using the following equation:

$$\text{Vitamin C (mg/100 ml)} = \text{Vitamin C (mol/l)} \times (\text{M.W}) \text{ of Ascorbic acid} \times 100.$$

Maturity indexes of apples

Estimation of starch index

Starch index was determined by the iodine test as following, iodine solution was prepared by dissolving (40 g KI and 10 g I₂) in one liter of distilled water. Fruits were cut with the greatest diameter and dipped into solution for 3 min, after then removed from the iodine solution, excess solution was drained and staining percentage estimated. The starch-iodine rating was conducted using the generic starch-iodine index chart for comparison. This method uses a 1 to 10 scale, where (0) represents the max starch content and (10) the complete degradation of the starch content (Szalay *et al.*, 2013).

Calculation of Thiault Index (TI)

The Thiault index (TI) was calculated from the measurements of TSS as a total sugar (TS) and titratable acidity (TA) expressed as malic acid (g/l), using the equation below (Icka and Damo, 2014).

$$TI = TS + (TA \times 10), TS \text{ (Total sugar)} = (TSS \times 10.6) - 20.6$$

Statistical analysis

Descriptive statistics analysis was performed to find the mean values and standard deviation (SD) of parameters. Duncan test was used as a multiple comparison test to express the differences between the average values at ($P \leq 0.05$). The statistical analysis was performed with the SPSS program version 16.

RESULTS AND DISCUSSION

Physical properties of apple fruits:

Fruit and its parts weight:

The minimum size of apple fruits shall be (60) mm, as a diameter, or (90) g, if measured by weight. Fruit of smaller sizes may be accepted if the °Brix value of the produce is (≥ 10.5) °Brix and the size is not smaller than (50) mm or (70) g (FFV-50, 2020).

In this study, the results revealed that, significant differences ($P < 0.05$) were observed among the physical properties of local and imported apple fruits varieties (Table 1). These results showed that the local apple had the higher fruits weight, flesh and peel weight compared to imported apple fruits, while the Honey crisp apple fruits had the lower values. The local apple fruit weight, flesh and peel weight were (122.04 ± 23), (109.16 ± 24.94) and (11.76 ± 2.84) g respectively; whereas, Honeycrisp apple fruit weight, flesh and peel weight were (102.94 ± 1.156), (89.7 ± 4.61) and (8.84 ± 1.30) g respectively. The weight of local apple fruits varied

widely from one fruit to the other. One for the reasons of this variation is that local apples fruits didn't sort or grade before its marketing. These results are in agreement with findings reported by Kassem *et al.*, (2016) on Anna apple fruit weight which was (123) g. Furthermore, Macitet *et al.*, (2021) researched to similar results. The results of this study were lower than findings of (El-Sabagh *et al.*, 2012, Zakia *et al.*, 2019; Kanchan *et al.*, 2020). However, it's higher than findings reported by Anwar *et al.*, (2020). In others studies, Jan and Davide, (2018) reported that the Red Delicious apple had higher fruits weight (213.64) g than Fuji and Granny Smith apples (204 and 202.08) g respectively.

The results demonstrated that, seeds were not existed in local apples fruit, while; presence in Honeycrisp apples, Granny Smith and Red Delicious apples with weight as 0.41 ± 0.07 , 0.31 and (0.14) g respectively (Table 1). The results obtained here indicated that the local apples fruits had two good physical properties compared to the imported apples, which were its high fruit weight and the absence of seeds. The differences between the present results and the findings of previous studies may be attributed to the growing conditions and geography of the study areas. Pre-harvest treatments such as foliar spraying of brassinoloide at (3 – 4) ppm improved some physicochemical properties of Anna apple such as the diameter, weight and color of the fruits (Attia and Adss, 2021).

The juice volume and juice yield ratio results for all apples varieties investigated showed no significant differences ($P < 0.0$) were observed. Red Delicious apple had the high juice volume and juice yield ratio, while Honeycrisp apples and the local apples had the low juice volume and low juice yield ratio respectively. The juice content of apples is an important parameter for industrial production of juices from fruits. The low juice yield ratio in local apple fruits may be related to the variation in maturity degree, moisture contents and firmness of local apple fruits. Higher volume juices contents in apple fruits (58%) was reported earlier by Kanchan *et al.*, (2020), while lower juice content (29.03%) by Agbaje *et al.*, (2020). In other studies, Jan and Davide, (2018) found high juices contents in Fuji apple (74.38) % compared to Red Delicious and Granny Smith apples which was (57.51) and (67.28) % respectively.

Fruits diameter and length

The results of fruits dimensions are shown in Table 2. The length/diameter ratio was significantly

different ($P < 0.05$) among apple fruits varieties. The local apple fruit had more length/diameter ratio (1.362); while, Granny Smith apple had less length/diameter ratio (0.952). Similar results are reported on Egyptian Anna apple (Anwar *et al.*, 2020) and Anna apple fruits (El-Sabagh *et al.*, 2012). In addition, Zakia *et al.* (2019) studied the fruit diameter and length apples and researched to similar results. Previously, Jan and Davide, (2018) reported that the fruit diameter was the more in Granny Smith apple (76.20) mm compared to Fuji and Red Delicious apples which were (74.38 and 76.14) mm respectively. Furthermore, Sotiropoulos and Syrgianidis, (2009) found that, fruit length/width ratio in Granny Smith apple was (0.81). These variations may be related to many factors including pre-harvest treatments, apples varieties and environmental conditions.

Physicochemical properties of apple fruit juice

Moisture and total solids

The moisture and total solids contents didn't differ significantly ($P < 0.05$) between local and imported apples varieties. The higher mean of moisture content was recorded as (86.27 ± 2.11) in Honeycrisp apple, while; the lower was (82.93 ± 3.93) in Granny Smith apple variety. The low moisture content (83.43 ± 2.13) of local apple fruit is an indicator for a good shelf life. These data are in agreement with results of Lee *et al.*, (2017) for the moisture in Fuji apple (85%) and lower than moisture content values reported in apples (90.02%) by Agbaje *et al.*, (2020). The moisture contents in apple fruits ranged between (80) and (85) % depends on cultivar type and the season of production (Guiné *et al.*, 2009). In this study, the total solid content in Golden delicious apple juice was (15.21%) and these results are in line with the finding of Rouchaud *et al.* (1986).

Titrateable acidity and pH value

The apples cultivars are grouped by classes according to their acid contents as: low-acidity class ($< 0.4\%$), intermediate-acidity apples (0.4 and 1.0%), and high-acidity apples ($> 1.0\%$) malic acid (Guiné *et al.*, 2009). Local and Granny Smith apples juice had the higher titrateable acidity value which were (0.53 ± 0.11 and (0.51 ± 0.24); while, Red Delicious and Honeycrisp apples juice titrateable acidity were (0.22 ± 0.04) and (0.22 ± 0.03) respectively (Table 3). The high value of acidity in local apples may be due to that local apples didn't reach to optimum maturity degree at harvest and its marketed fresh after harvesting without any treatments or storage periods.

The Anna apple fruits are characterized by its high acidity content. This acidity content was decreased gradually and significantly from harvest to storage and post-storage shelf life periods (Nagy, 2018; Singh *et al.*, 2017). Klein and Lurie (1990) found that the acidity of Anna apple fruits at harvest was (0.66) % and it decreased after two months of storage at 0°C to (0.55%). Moreover, they reported that the titrateable acidity was reduced in Granny Smith and Anna apple fruits that treated with heat treatment for 4 days before storage. In other hand, the results of acidity in local apple fruits are similar to those previously reported on Egyptian Anna apples (Anwar *et al.*, 2020), and Granny Smith apples (Bongers *et al.*, 1994). Furthermore, higher acidity in Anna apple fruits was previously reported by (Kassem *et al.*, 2016, Attia and Adss, 2021 and El-Sabagh *et al.*, 2012). In addition, Lee *et al.*, (2017) and Zakia *et al.*, (2019) found the titrateable acidity in Fuji apple and Red Delicious apple were (0.39) and (0.42) % respectively.

In current study, the results revealed that, the local apple and Granny Smith apple juice had the low pH values which were (3.61 ± 0.12) and (3.69 ± 0.29) respectively; while; the pH of Red Delicious and Honeycrisp apples were (4.10 ± 0.05) and (4.2 ± 0.35) respectively (Table 3). These results are in line with findings of Abdualrahman (2015) and with Sotiropoulos and Syrgianidis, (2009) who reported the pH value in local apple fruit juice was (3.90%), but it's lower than the pH in imported apple fruit juice (4.18%). Macit *et al.*, (2021) reported that, local apple varieties from Anatolia (3.72 - 4.18%). However, the pH value was 3.24 and 3.60 in Golden delicious apple juice and in apple fruits respectively as mentioned by Rouchaud *et al.* (1986) and Kanchan *et al.*, (2020) .

Total soluble solids ($^\circ\text{Brix}$)

Total sugar concentration and TSS measurements represent good tools to define the maturity degree of apple fruits (Wosiacki *et al.*, 2007). The results obtained in current study showed that the local apples juice had the highest total soluble solid content (83.43 ± 2.13) $^\circ\text{Brix}$, while the Granny Smith apples juice had the low TSS content (10.85 ± 1.60) $^\circ\text{Brix}$ (Table 3). These results are closed to those found in Egyptian Anna apple variety (12.67 and 12.83%) and (12.53 and 12.30%) by Anwar *et al.* (2020) and Attia & Adss (2021).

These results are fallen in the range of Bongers *et al.*, (1994) for apple fruits from different origins that sold in European markets which were (11.25 - 15.60) %. They reported that the TSS values were (12.40- 14.15), (11.25- 14.08), (11.41-

12.61) % in Delicious, Golden Delicious and Granny Smith apples respectively. Almeida and Gomes, (2017) reported that the TSS value in Granny Smith and Fuji apples was (10.8) and (13.9) % respectively. These results are similar to the results of TSS in local apple fruits from Sudan (13.80) % (Abdualrahman, 2015). In other studies, Kanchan *et al.*, (2020) found the TSS in apple fruits was (11.50) °Brix. Low TSS contents in Anna apple fruits was reported by Kassem *et al.*, (2016) as 10.8 % and by El-Sabagh *et al.*, (2012) as 9.96 and 10.75 % at 2008 and 2009 seasons respectively. Meanwhile, Macit *et al.*, (2021) found the TSS in local apple from Anatolia was ranged between (7.07 - 8.93) %.

The mean of TSS tended to increase with the progression of either cold storage or post-storage shelf life periods (Nagy, 2018). Fruits with higher TSS content typically have more intense sweaty and juicy (Alwaseai and Al-Gaber, 2023). However, higher TSS value was found by BateljaLodeta *et al.*, (2019) in traditionally grown domesticated apple varieties from Croatia, which was ranged between (14.97 – 20.27) Brix and by Zakia *et al.*, (2019) for Red Delicious apple juice TSS was (14.29) %. Bongers *et al.*, (1994) reported that the TSS were (11.41 – 12.61) % in Granny Smith apples, while Jan and Davide, (2018) found that, the highest TSS content was in Fuji apple compared with Red Delicious and Granny Smith apples, by (13.61, 13.39 and 13.0) °Brix respectively.

Vitamin C (Ascorbic acid):

The vitamin C content in Anna apple fruits was significantly decreased with advanced storage and post-storage shelf life periods to reach the least content after three months of cold storage (Nagy, 2018). The results in Table 3 showed that the ascorbic acid didn't differ significantly ($P < 0.05$) among all apples varieties included in this study.

The local apples, Granny Smith, Red delicious and Honeycrisp juice ascorbic acid content were (16.01 ±3.57), (15.72 ±2.59), (17.46 ±1.82) and (17.61±3.37) mg/100 ml respectively. Previously, studies reported that, low values of vitamin C in apples varieties ranged between 1.28-22.10 mg/100 ml; Zakia *et al.*, 2019; Attia and Adss, 2021; Macit *et al.*, 2021).

Reducing sugars content

Sugars content in apple fruits increased gradually during fruit development. The sugars are quantitatively or qualitatively converted to other sugars. Conversion of polysaccharides into sugars during growth and development lead to increase the

sugar content in fruits. This conversion has a great impact on the fruit quality (Dar *et al.*, 2021).

The results of this study showed that no significant differences ($P < 0.05$) were found in reducing sugar content among local, Honeycrisp and Red Delicious apple varieties, while the reducing sugar content of Granny Smith apple juice was significantly differing than other apple varieties measured in this study. The mean value of reducing sugar content was (8.32±0.96), (6.59± 0.32), (8.69±0.53) and (8.84±0.93) in local, Granny Smith, Red Delicious and Honeycrisp apples respectively (Table 3). These results are similar to findings reported by Kanchan *et al.* (2020), and Batelja Lodeta *et al.*, (2019) who studied the reducing sugar content in traditionally grown domesticated apple varieties from Croatia. The contrary between the present results and previous studies findings may be attributed to the differences in the treatments that apply for apples fruits. Rouchaud *et al.*, (1986) cited that treatments of apple fruits with fungicide raised the total sugars content by 22% in Golden Delicious apple.

Maturity indexes

Consumer perception of sweetness or sourness is determined not only by the concentration and type of sugars and acids, but also by the relative proportion of each. Two indices have been used in apple to describe the relationship between sugars and acids and express taste equilibrium: the simple ratio between SSC and TA and the Thiault index (Almeida and Gomes, 2017). The chemical composition of apple fruits and their acid and sugar contents depends on their maturity stage (Guiné *et al.*, 2009). The results of the maturity indexes of local and imported apples fruit investigated in this study are showed in (Table 4).

TSS/TA ratio

The TSS/TA ratio in apple fruits is used as indicator to determine the fruits sweetness. The fruits that have a high TSS/TA ratio are considered sweet, whereas the fruits with low ratio are perceived as sour.

The results in Table 4 showed that TSS/TA mean ratios was (26.92 ±4.20) and (24.88 ±9.90) in local and Granny Smith apples respectively, whereas; 55.39 ±9.69 and 54.58 ±9.87 in the Honeycrisp and Red Delicious apples respectively. The low TSS/TA mean ratio in local apple fruits may be related to their high level of acidity, It's mean that the local apples contain high concentration of organic acids.

The organic acids contents in apple fruits are an important parameter in maintaining the quality of fruits. Some treatments for apple fruits effect on their TSS/TA ratio. The TSS/TA ratio was significantly decreased in calcium treated "Jona gold" fruits compared to the control fruits (Rabiei *et al.* 2011). The other reason of low TSS/TA ratio for local apple fruits may be due to the early harvesting before they reached to the optimum maturity. During ripening process some starch content in apples are converting to sugar which caused the increase in the TSS value, while the organic acids are consumed in plant respiration so the acidity are decreased (Cepeda *et al.*, 2021).

These results were in agreement with the findings of Almeida and Gomes, (2017) who reported that the high mean ratios of TSS/TA in Starking and Fuji cultivar of apples which were (66%) and (70%), while the low values were found in Granny Smith and Reinette apples (18%) and (21%) respectively. These results also in parallel with findings of Bongers *et al.*, (1994) who studied the solids/acidity ratio in Granny Smith and Fuji apples from European markets. In elsewhere studies, Icka and Damo, (2014) reported that the sugar/acidity ratio for Red Delicious at harvesting time was ranged between 33.007 and 52.473 according to harvest time and suggested that the optimum sugar/acidity ratio for Red Delicious harvesting is 40 -50.

Starch- iodine index

The characteristic patterns of starch degradation differ between apple cultivars (Fan *et al.*, 1995). The starch iodine index value is low at harvest of apple fruits. This value indicates high starch content which decreases over the course of ripening due to its hydrolysis in fructose and glucose leading to high values of the starch iodine index (Daniela and Vanessa, 2020).

Results in Table 4 displayed that the starch-iodine index for local apples had a significant difference ($P < 0.05$) compared to the imported apples varieties which was (7.67 ± 2.88) and (10.0 ± 0.0) respectively. This means that the local apples had high starch content and the starch hydrolysis degree didn't reach to the maximum, whereas in the imported apples the starch was completely hydrolyzed. The high starch content in local apples may be due to low sweetness (Figure, 2). These results are in line with findings of Singh *et al.*, (2017) who reported that the starch content was the high at harvest of Anna in comparison to Galaxy and GD apples and this content of starch are declined during storage period. In study in Egypt, the reported starch index of Anna apples was (6.78) and

(6.42), during the 2016 and 2017 seasons respectively (Serry *et al.*, 2019). The low value of starch index in local apple may be related to the early harvesting for local apple fruits and freshly marketed without storage periods, whereas imported apple varieties were taking suitable time from harvested, storage and marketing time. This storage period encourages degradation of starch in apples and conversion to sugars. The significant difference in starch index values between local and imported apples may relate to the variations in growing conditions such as the temperature during growth period and the variations of apples cultivar. Starch conversions to sugar are depends on temperature degree with a negative correlation between the rate of starch hydrolysis and temperature (heat units) over a period of several weeks before first acceptable harvest. Low temperature encourages the starch conversion to sugar. The test was not useful for late maturing cultivars because there was little starch loss at harvest, that is, during the normal harvesting season (Smith *et al.*, 1979). Starch degradation pattern varied between apples cultivars, so separate charts for each group of apples is recommended for use in practice (Szalay *et al.*, 2013).

Some changes in apple fruit properties are occurred during the maturation progress, which the TSS content and starch pattern index increased. The change in TSS was small compared to that of the starch pattern index, so the starch pattern index could be a reliable parameter for determine harvest time and for evaluates maturity at harvest (Reid *et al.*, 1982). The apple fruits sweetness quality influenced by the degree of starch degradation, sugar translocation and accumulated of sugar content (Thammawong and Arakawa, 2009).

Thiault index (TI)

Thiault index is one of the fruit quality indicators. It's used to determine the optimum ripeness of apple fruits at harvest and fruit storability. Thiault index (TI) can be used as a tool for determine the acceptability of apple juice because it produce results qualitatively similar to the sensory scores (Rouchaud *et al.*, 1986).

The results in Table 4, showed a significant difference ($P < 0.05$) in Thiault index (TI) between local and imported apple fruits. The Thiault index (TI) values were 183.86 ± 24.65 , 150.91 ± 41.43 , 132.86 ± 19.89 and 127.24 ± 15.32 in local apple, Granny Smith, Red Delicious and Honeycrisp apples respectively. Almeida and Gomes, (2017) reported Thiault index (TI) in Granny Smith and Fuji apple fruits as 168 and 159 respectively, while

Sotiropoulos and Syrgianidis, (2009) found Thiault index (TI) in Granny Smith apples as 182.

The high TI value for local apples indicates that local apples had high storability but didn't indicate they have more sweetness than imported apple fruits. These results revealed that the Thiault index (TI) couldn't be used as a right indicator for

the fruits sweetness because the local apples had the highest TI value but their sweet taste was lower compared to Red Delicious and Honeycrisp apple fruits. The TSS/TA ratio and starch index are better than TI as an indicator for the fruit's quality in term its sweet taste.

Table 1. Whole fruits and its parts weights and the juice volume of local and imported apple

Parameter	Apple variety			
	Local	Granny Smith	Red Delicious	Honeycrisp
Fruit weight (g)	122.04 ± 23 a	113.50 ± 11 ab	117.68 ± 6.34 ab	102.94 ± 1.156 b
Flesh weight (g)	109.16 ± 24.94 a	98.59 ± 9.52 ab	102.77 ± 6.96 ab	89.7 ± 4.61 b
Peel weight (g)	11.76 ± 2.84 a	11.62 ± 2.36 ab	10.92 ± 1.20 ab	8.84 ± 1.30 b
Seeds weight (g)	0.0 b	0.31 ± 0.25 a	0.14 ± 0.10 b	0.41 ± 0.07 a
Juice volume (ml).	47.83 ± 15.24 ab	52.50 ± 12.97 ab	57.83 ± 9.75 a	41.70 ± 10.23 b
Juice yield% (V/W).	38.66 ± 6.60 a	45.89 ± 8.38 a	49.03 ± 7.16 a	40.44 ± 9.59 a

Different letters within a row mean significant difference ($P < 0.05$).

Table 2. Length and diameter of local and imported apple fruits

Parameter	Apple variety			
	Local	Granny Smith	Red Delicious	Honeycrisp
Fruit diameter (mm)	51.3 ± 4.7 b	56.7 ± 2.4 a	54.8 ± 1.7 ab	54.2 ± 2.3 ab
Fruit length (mm)	69.7 ± 6.4 a	54.0 ± 7.7 c	62.7 ± 4.4 ab	56.3 ± 5.1 cb
Length/diameter ratio	1.362 ± 0.12 a	0.952 ± 0.10 c	1.143 ± 0.07 b	1.042 ± 0.09 bc

* Different letters within a row mean significant difference ($P < 0.05$).

Table 3. Physicochemical properties of apples juice

Parameter	Apple variety			
	Local	Granny Smith	Red Delicious	Honeycrisp
Moisture	83.43 ± 2.13 a	82.93 ± 3.93 a	84.40 ± 1.69 a	86.27 ± 2.11 a
Total solid	16.57 ± 2.13 a	17.07 ± 3.93 a	15.77 ± 1.94 a	13.73 ± 2.11 a
Total soluble solid (°Brix)	13.82 ± 1.34 a	10.85 ± 1.60 b	12.15 ± 1.57 ab	11.68 ± 1.39 b
Acidity as (malic acid)	0.53 ± 0.11 a	0.51 ± 0.24 a	0.22 ± 0.04 b	0.22 ± 0.03 b
pH	3.61 ± 0.12 b	3.69 ± 0.29 b	4.10 ± 0.05 a	4.2 ± 0.35 a
Vitamin C (mg/100 ml)	16.01 ± 3.57 a	15.72 ± 2.59 a	17.46 ± 1.82 a	17.61 ± 3.37 a
Reducing sugar (g/100 g)	8.32 ± 0.96 a	6.59 ± 0.32 b	8.69 ± 0.53 a	8.84 ± 0.93 a

Different letters within a row mean significant difference ($P < 0.05$).

Table 4. Maturity indexes for apple fruits

Parameter	Apple variety			
	Local	Granny Smith	Red Delicious	Honeycrisp
TSS/TA	26.92 ± 4.20 b	24.88 ± 9.90 b	55.39 ± 9.69 a	54.58 ± 9.87 a
Starch index	7.67 ± 2.88 b	10.0 ± 0.0 a	10.0 ± 0.0 a	10.0 ± 0.0 a
TI	183.86 ± 24.65 a	150.91 ± 41.43 b	132.86 ± 19.89 b	127.24 ± 15.32 b

Different letters within a row mean significant difference ($P < 0.05$).

CONCLUSIONS:

Local apple fruits characterize by its high fruit weight and size. It's containing high TSS, total solids, titratable acidity compared to imported apples. The low TSS/TA ratio and starch iodine index in local apple indicated that local fruit harvested early. The low TSS/TA ratio and low starch index in local apple may be the reasons of its low sweet taste. The sweet taste in imported apples

COMPETING INTERESTS

Authors have declared that no competing interests exist.

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دراسة مقارنة الخصائص الفيزيوكيميائية لفاكهة التفاح المحلي والتفاح المستورد في اليمن

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الملخص

هدفت الدراسة إلى تقدير الخواص الفيزيائية والكيميائية للتفاح المحلي (صنف Anna) وثلاثة أصناف من ثمار التفاح المستوردة شملت اصناف (Honeycrisp و Red Delicious و Granny Smith) لمقارنة خواص جودة التفاح المحلي مع التفاح المستوردة. تم جمع العينات من الأسواق المحلية في مدينة ذمار، اليمن. أظهرت نتائج الدراسة أن الخواص الفيزيائية لثمار التفاح كانت: متوسط وزن الثمرة الكامل (122.04 و 113.5 و 117.68 و 102.94) جرام و متوسط وزن اللب (109.16 و 98.59 و 102.77 و 89.7) جرام و متوسط وزن القشرة (11.76 و 11.62 و 10.92 و 8.84) جرام، في حين كان متوسط وزن البذور (0.0 و 0.31 و 0.14 و 0.41) جرام، بينما كان حجم مستخلص الثمرة (47.83 و 52.50 و 57.83 و 41.70) مل لأصناف التفاح المحلية و Red Delicious و Granny Smith و Honeycrisp على التوالي. أما الخصائص الكيميائية لعصير التفاح فكانت النسبة المئوية للرطوبة (83.43 و 82.93 و 84.40 و 86.27)% و نسبة المواد الصلبة الكلية (16.57 و 17.07 و 15.77 و 13.73)% و نسبة المواد الصلبة الذائبة (TSS) (13.82 و 10.85 و 12.15 و 11.68) بركس و نسبة السكريات المختزلة (8.32 و 6.59 و 8.69 و 8.84)% و الرقم الهيدروجيني (3.61 و 3.69 و 4.10 و 4.2) والنسبة المئوية لحموضة التصحيحية (TA) (0.53 و 0.51 و 0.22 و 0.22) %، بينما بلغت نسبة فيتامين (C) (16.01 و 15.72 و 17.46 و 17.61) (ملغم/100مل) في أصناف التفاح المحلية و Red Delicious و Honeycrisp على التوالي. كما اظهرت النتائج لقيم مؤشرات النضج للثمار والتي شملت النسبة بين المواد الصلبة الذائبة (بركس) الى الحموضة (TSS/TA) (26.92 و 24.88 و 55.39 و 54.58) و مؤشر النشأ (7.67 و 10 و 10 و 10) و مؤشر Thiault index (TI) (198.28 و 2164.3 و 149.67 و 143.92) في أصناف التفاح المحلية و Red Delicious و Granny Smith و Honeycrisp على التوالي. نستنتج من نتائج هذا البحث الى أن ثمار التفاح المحلي تتمتع بمؤشرات جودة جيدة، من حيث خصائصها الفيزيائية و محتواها المرتفع من المواد الصلبة الذائبة (TSS)، إلا أن النسبة العالية من الحموضة و النشأ قد تكون من أسباب انخفاض حلاوتها و يؤثران سلبياً على خصائص جودة التفاح.

الكلمات المفتاحية: التفاح الاخضر، الخواص الفيزيائية والكيميائية، التفاح اليمني، تفاح آنا، التفاح الاحمر، التفاح السكري.

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Original Article

The Effect of Zeolite and Organic Acids Supplement on the Performance, Carcass Traits and Blood Parameters of Broiler Chickens

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KEYWORDS

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ABSTRACT

The present study was carried out at Poultry Research Station, Faculty of Agriculture and Veterinary Medicine, Thamar University, with aim to study the effect of dietary supplementation of zeolite and organic acids on the performance of broiler chickens. One hundred eight one-day old broiler chicks (Ross) were purchased and randomly divided into 4 experimental groups each group containing 3 replicates with 9 birds in each replicate.: T1 received basal diet and acts as control, T2 received 2% Zeolite, T3 received acidified drinking water by 1% blend of organic acids and T4 received 2% zeolite with acidified drinking water by 1% blend of organic acids. In the starter period (0-3weeks), the best FCR was for the zeolite group and combined group compared to acidified group and control group, but in the grower period (3-6 weeks) the best FCR was in group of blends with organic acids and combined group than the other treatments. Concerning whole experimental period (0-7 weeks) feed intake and weight gain were better in groups of zeolite and blend of organic acids followed by group of combined supplementations than the control group, however; at the end of the experiment the three treated groups recorded the best FCR indices compared to control. This can prove that supplementing diet had a significant ($P<0.05$) effect on parameters of growth performance. There were significant differences ($P<0.05$) in the mean value of carcass at the end of experiment, combined group had the best carcass value followed by blend of organic acids and zeolite groups than control. Regarding the weight of heart, liver, spleen, gizzard and proventriculus, organic acids group recorded higher weights followed by zeolite and combined groups than control group. Total protein was significantly ($P<0.05$) higher in treated groups. however, the blood cholesterol and triglycerides decreased significantly. The results also revealed that, serum urea and creatinine were lower in treated groups than control. It can be concluded that supplementing broiler diets with zeolite in feed and organic acids in water either alone or in combination have a significant effect on broiler performance, carcass traits and blood parameters, and they have a preferable effect to consumers. So these additives can be used efficiently in broiler diets.

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INTRODUCTION

Poultry industry is considered as one of the main suppliers of human's animal protein. This industry is rapidly growing and is facing a future without benefit of some biologically and economically effective feed additives. Feed represents 60-70% of the total cost of poultry production. For this reason, the efficient use of feed is extremely important in

broiler production (Llanes and Ramirez 2022). For many years' antimicrobial compounds have been used in poultry industry to improve health status and performance of birds by reduction or correction of the population of the bacteria present in the gastrointestinal tract (Smith *et al.*, 1999, Stahl *et al.*, 2000, Thompson *et al.*, 2000). Questioning use of

antibiotic growth promoters (AGPs) in animal production has resulted in withdrawal of these feed additives in the Europe. Consequently, interest in feed additives that may act as alternatives for AGPs is growing (Papatsiros, *et al.*, 2013), but the lack of incentives for pharmaceutical companies to invest in their development remains a significant barrier (Callaway *et al.*, 2021). Zeolites have the ability to gain and lose water reversibly and to exchange constituent ionic cations without major changes of structure. It contained almost 88% calcium-rich clinoptilolite, which is a naturally occurring zeolite that belongs to a family of crystalline aluminosilicate minerals. They have a 3-dimensional, porous structure that is responsible for specific cation exchange capacity. Finally, clinoptilolite's antioxidant effects and restoration of antioxidant defense mechanisms may also be linked to the positive general systemic impact (Pavelic *et al.*, 2018). There has been recent interest in the use of natural zeolites as a feed additive and as a means of reducing odor and ammonia emissions from broiler houses (Simona and Camelia 2019).

Organic acids work in poultry, not only as a growth promoter but also as a meaningful tool of controlling all enteric bacteria, both pathogenic and non-pathogenic (Wolfenden *et al.*, 2007). Moreover, organic acids feeding is believed to have several beneficial effects such as improving feed conversion ratio, growth performance, enhancing mineral absorption and speeding recovery from fatigue. Contrary to antibiotics, organic acids have other properties like; lowering of the chime pH consequently, enhancing of protein digestion (Brzoska *et al.* 2013, Simona and Camelia 2019, Ali *et al.*, 2020). Little data are available on performance of broiler chickens fed with organic acids and zeolite. Therefore, this study was conducted to investigate the effects of dietary supplementation with natural zeolite (clinoptilolite) in feed and the organic acids acidified drinking water, either alone or in combination on the performance, carcass traits and blood parameters of broilers.

MATERIALS AND METHODS

Table 1. Summarizes the suggested experimental

T &G	Cntrl	Ze	AOs	Ze & OA
Comm. diet	+	+	+	+
Ze in feed	-	+	-	+
OA in water	-	-	+	+

design

T&G=Treatment, Ctrl=Control, Ze=zeolite, O.Acid

This An experiment was conducted at Division of Veterinary Medicine, Faculty of Agriculture and Veterinary Medicine, Tamar University to study the effect of supplementing broiler diets with zeolite in feed or organic acids in drinking water individually or in combination on the performance, carcass traits and blood serum parameters of broilers during rearing period of broilers (1- 49 days). The Zeolite used in this experiment is a product of Yemen zeolite company and contains clinoptilolite as the active substance, and the blend of organic acids was a commercial acidifier (ACPure®) imported by Yemen Ayadi, and consists of formic, propionic, citric, and lactic acids.

Experimental Chicks and housing

A total number of 108 one-day old of mixed Ross chicks obtained from a local commercial source. Experimental birds were individually weighed (averaged 45 g/ bird). The birds were randomly allotted into four groups, each of 27 chicks with three replicates with 9 chicks in each replicate. All groups were reared under standard managemental condition. The prophylactic measures were taken to control diseases and to increase the viability of the birds. The experimental room of the broilers house properly prepared, disinfected with 4% formalin and divided into four separated compartments of equal size (1.5 x 2m) each of 3 m². The floor area was bedded by a layer of chaffed sawdust. Experimental compartments were equipped with cylindrical hanging feeders, water fount, gas brooders, all the bird groups were subjected to 24 hours lighting which extended to the age of 7 weeks. Room temperature maintained by gas brooders at 34°C during the first three days and gradually decreased by 0.5°C daily till it reaches 25°C at the end of the third week, then it maintained at 24°C thereafter till the end of the experiment.

Chicks were investigated to evaluate the effect of supplementing broiler diets with zeolite in feed and/or with acidified drinking water by organic acids for the period of 1-49 days of age on growth performance, carcass traits and blood biochemistry. 1st group, birds were fed with broiler starter and grower commercial diet, 2nd, 3rd and 4th groups were receiving zeolite in feed, zeolite with organic acids in feeds and water respectively as presented in Table 1. All experimental diets were formulated to meet the nutrient requirements according to NRC (1994) recommendation for broilers.

Growth performance and feed conversion

Chicks were weighed weekly, live body weight (LBW) and feed consumption was recorded to calculate the body weight gain (BWG) and feed conversion ratio (FCR). The amount of feed consumed was weekly recorded in each bird of the different experimental groups. The average amount of feed intake (FI) by each bird was calculated by dividing the weekly consumed feed by its respective number of living birds in each group at this week.

Regarding the development of the body weight and weight gain, the birds were individually weighed every week and the live weight changes were taken as the criteria of the effect of the different treatments, and as a measure for growth, the amount of feed consumed was divided by the body weight gain of the bird in order to calculate the rate of feed conversion.

Carcass traits and blood samples

Five birds were randomly selected from each group and slaughtered at the end of the experimental period for carcass traits and for blood samples collection. Birds were prohibited from feeding, but not for drinking 12 hours prior slaughtering. The weights of Carcass and internal organs of birds including gizzard, liver and heart were recorded individually at the end of the experiment.

A blood samples were collected from each slaughtered birds of all groups at the end of the experiment. The blood samples were allotted to clot at ambient temperature, centrifuged for 10 minutes at 3000 rpm, and serum from each sample was extracted. The serum samples (1ml/vial) were kept at -20°C until biochemical parameters were measured.

Blood biochemistry

Biochemical parameters, including total serum protein and its fractions (albumin and globulin), cholesterol, triglycerides, urea and creatinine were determined using standard test kits supplied by SGM (Roma / Italia).

Statistical analysis

Analysis System (SPSS Inc., Chicago, IL, USA), for analyzing the data were used. The differences ($P < 0.05$) among treatment means groups were tested using Duncan's multiple range test.

RESULTS AND DISCUSSION

The effect of zeolite feed or/and organic acids supplement on performance of broilers are presented in Table 2. In the starter period (0-3weeks), there were significant effects ($P < 0.05$) on LBW, BWG, FI

and FCR. It was obvious in this period that birds in the groups of zeolite and the blend of organic acids showed significantly better feed intake and weight gains but the best FCR was for the zeolite group and the combined group than the acidified water group and the control.

Also, there was a significant effect ($P < 0.05$) observed in the grower period (3-6 weeks) and entire period (0-7weeks) for the groups of zeolite and the blend of organic acids which recorded better feed intakes and weight gains but the best FCR in the grower period was for the groups of blend of organic acids and the combined group (Table 2).

Concerning the whole experimental period (0-7 weeks) feed intake was better in the groups of zeolite and the blend of organic acids followed by the group of combined supplementation than the control, (Figure 1). Weight gain also was better in the groups of zeolite and the blend of organic acids followed by the group of combined supplementation than the control (Figure 2). At the end of the experiment, the three treated groups (the zeolite, the blend of organic acids and the group of combined supplementations) showed ($P < 0.05$) the best FCR indices than the control as presented in Table (2). This study agreed with the other studies which proved earlier that the addition of zeolite or an organic acid-plus-zeolite to the diet, had positive effects on the performance of broilers (Garcia *et al.* 2007, Levic *et al.* 2008, Suresh *et al.*, 2018, Abaş *et al.*, 2011).

The positive effect of zeolite on broiler performance might be attributed to its chemical characteristics by reduction toxic effects of aflatoxins, ammonia and hydrogen sulfide and reduced bacterial contamination of intestine due to its high absorption capacity. Furthermore. Zeolite contained minerals (macro- and microelements) which in an ionic state exist and can be beneficial for birds' growth (Amad, & Al-ansi, 2018). VasiljevI, *et al.* (2021) suggested that zeolite is useful in the elimination of a variety of contaminants from the body or in amelioration of the intestinal status (VasiljevI, *et al.*, 2021).

In the present study, There were significant differences in the Mean value ($P < 0.05$) of carcass at the end of this experiment, the group of combined supplementation had the best carcass mean value followed by the blend of organic acids and the zeolite groups compared to control group. These results are in accordance with findings reported by Abbasi *et al.*, (2018). Regarding the weight of heart liver spleen gizzard and proventriculus, mean values were increased significantly ($P < 0.05$) in the treated groups compared to control. The organic acids group recorded higher weights followed by the zeolite and

the combined groups compared to control group, as presented in Table 3. Total protein mean value was significantly ($P < 0.05$) higher in the treated groups. However, the blood cholesterol and triglycerides decreased significantly. Serum urea and creatinine

were lower in the treated groups compared to control (Table 4). These results in agreement with findings of Abaş et al. (2011).

Table 2. Effect of zeolite and organic acids on feed intake, body weight, feed conversion rate in broiler chickens

Stage	Experimental treatments			
	Control	Zeolite	Organic Acids	Z. & O.A.
	Feed intake (g/bird)			
(0-3 weeks)	797.89	823.03	820.63	788.67
(3-6 weeks)	2339.31	2569.33	2538.97	2486.08
(6-7 weeks)	1145.89	1059.56	1074.27	1075.63
(0-7 weeks)	4283.09	4451.92	4433.87	4350.38
	Body weight gain (g/bird)			
(0-3 weeks)	379.13 ± 6.38 ^b	400.44 ± 7.45 ^a	384.72 ± 6.74 ^{ab}	381.85 ± 6.25 ^{ab}
(3-6 weeks)	1117.16 ± 17.70 ^b	1264.27 ± 21.62 ^a	1279.48 ± 19.11 ^a	1246.16 ± 20.43 ^{ab}
(6-7 weeks)	543.08 ± 13.99 ^b	540.59 ± 12.05 ^b	556.62 ± 14.80 ^a	551.61 ± 12.97 ^a
(0-7 weeks)	2039.37 ± 31.14 ^c	2205.30 ± 33.23 ^a	2220.82 ± 37.59 ^a	2179.62 ± 32.73 ^a
	FCR (g/g):			
(0-3 weeks)	2.1	2.05	2.13	2.06
(3-6 weeks)	2.09	2.03	1.98	1.99
(6-7 weeks)	2.11	1.96	1.93	1.95
(0-7 weeks)	2.10	2.02	1.99	1.99

*Letters in the same row having the same superscripts are not significantly different ($P < 0.05$)

Table 3. Mean weights of dressed carcass and some internal organs of broilers supplemented with zeolite in feed or/and organic acids in water

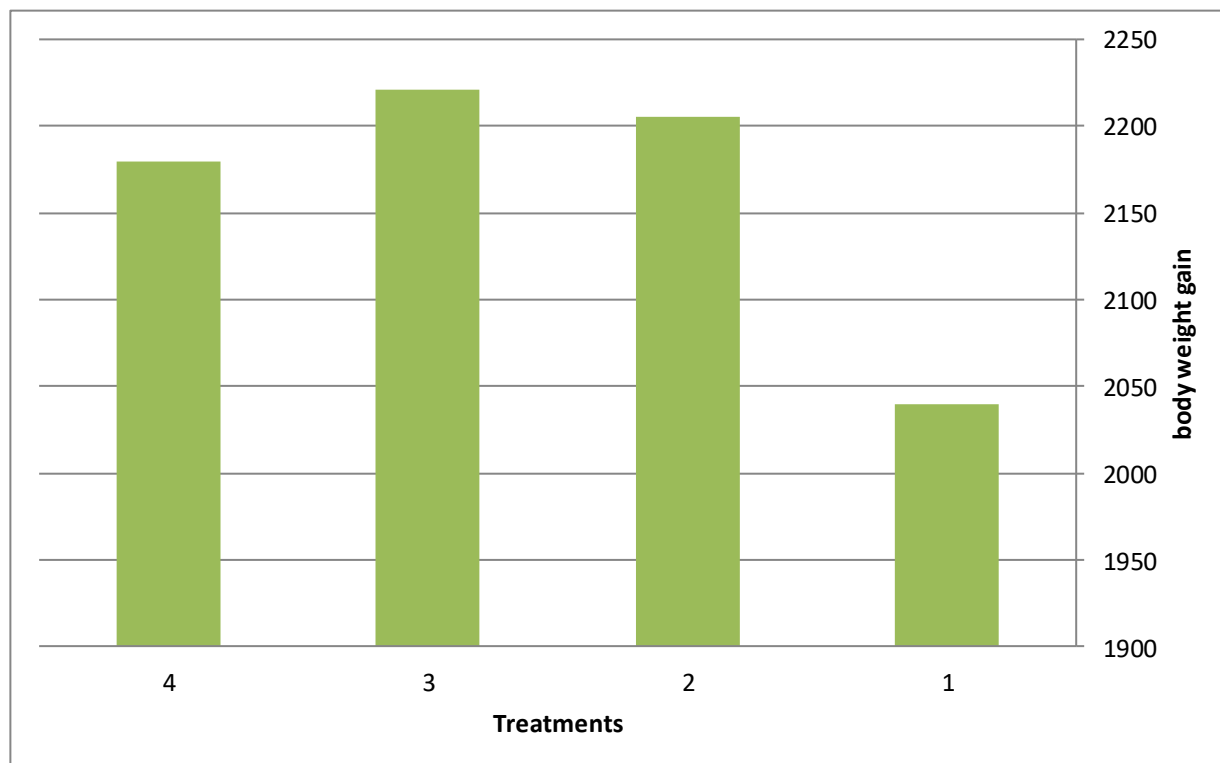
Item	Experimental treatments			
	Control	Zeolite	Organic acids	Z. & O.A.
Dressed carcass	71.46 ± 0.93 ^c	72.1 ± 1.11 ^b	72.67 ± 0.91 ^{ab}	72.94 ± 1.02 ^a
Heart	0.490 ± 0.02 ^{bc}	0.478 ± 0.04 ^c	0.517 ± 0.04 ^a	0.510 ± 0.04 ^{ab}
Liver	2.25 ± 0.04 ^c	2.27 ± 0.05 ^{bc}	2.32 ± 0.05 ^a	2.29 ± 0.03 ^b
Spleen	0.153 ± 0.01 ^b	0.158 ± 0.01 ^{ab}	0.168 ± 0.03 ^a	0.166 ± 0.03 ^a
Gizzard	1.490 ± 0.08 ^b	1.480 ± 0.05 ^b	1.630 ± 0.05 ^a	1.620 ± 0.04 ^a
Proventriculus	0.406 ± 0.01 ^b	0.420 ± 0.01 ^{ab}	0.430 ± 0.01 ^a	0.421 ± 0.02 ^{ab}

*Letters in the same row having the same superscripts are not significantly different ($P < 0.05$).

Table 4. Mean blood parameters of broilers supplemented with zeolite in feed or/and Organic acids in water

Item	Treatments and control groups			
	Control	Zeolite	Organic acids	Z. & O.A.
Cholesterol (mg /dl)	114.13±0.6 ^b	107.34±0.6 ^{ab}	104.06±0.92 ^b	102.12±0.6 ^b
Triglycerides (mg /dl)	68.44±0.65 ^a	65.44±0.41 ^a	59.98±0.96 ^c	62.65±0.18 ^{ab}
T-protein (g / dl)	4.32±0.18 ^b	4.54±0.04 ^{ab}	4.74± 0.19 ^a	4.64± 0.20 ^a
Albumin (g / dl)	2.18± 0.07 ^b	2.30± 0.08 ^{ab}	2.48± 0.04 ^a	2.37± 0.19 ^a
Globulin (g / dl)	2.14± 0.21 ^b	2.21± 0.03 ^{ab}	2.26± 0.15 ^a	2.27± 0.20 ^a
Urea (mg/dl)	2.14± 0.04 ^a	1.92± 0.05 ^b	1.98± 0.07 ^{ab}	1.97± 0.03 ^{ab}
Creatinine (mg/dl)	0.19± 0.02 ^a	0.17± 0.04 ^a	0.15± 0.01 ^{ab}	0.14± 0.02 ^b

*Letters in the same row having the same superscripts are not significantly different ($P < 0.05$).

**Fig. 1. Body weight gain (gm) of broilers supplemented with zeolite in feed and organic acids in water**

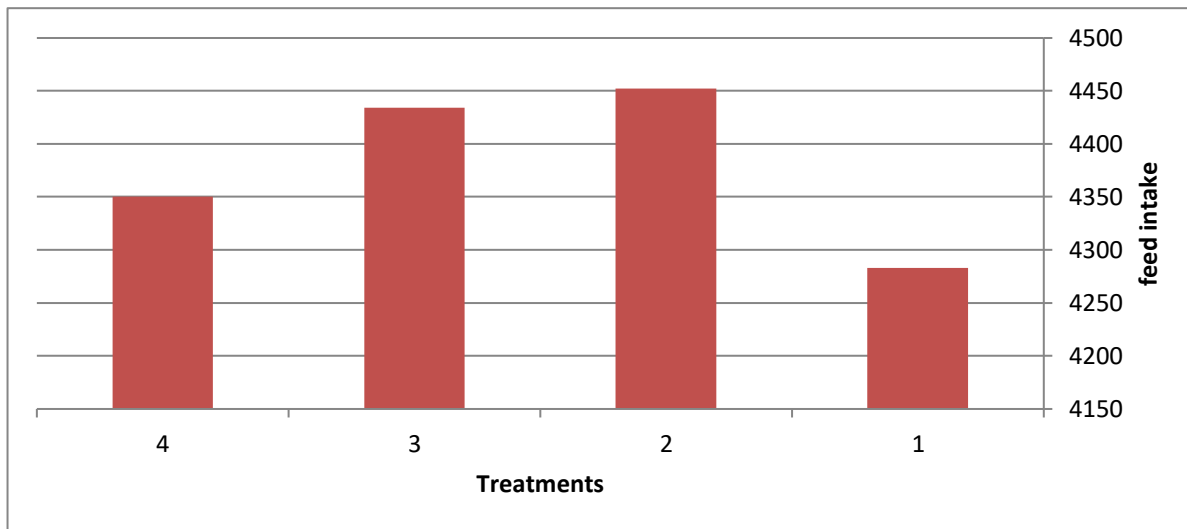


Fig. 2. Feed intake (gm) of broilers of broilers supplemented with zeolite in feed and organic acids in water

CONCLUSION

The present results showed that there are a positive and significant effect of supplementing the broiler diets with zeolite in feed and organic acids in water either alone or in combination on broiler chickens in terms of growth performance, carcass and blood parameters, and they have a preferable effect on to consumers. Thus, these additives can be used efficiently in broiler diets.

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CONFLICTS OF INTEREST

The authors of this article declare that no conflict of interest regarding to this article.

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تأثير اضافة الزيوليت والأحماض العضوية على الأداء وصفات الذبيحة وقياسات الدم في دجاج اللحم

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الملخص

أجريت الدراسة الحالية في المحطات البحثية التابعة لكلية الزراعة والطب البيطري جامعة ذمار، بهدف دراسة تأثير الزيوليت والاحماض العضوية على الأداء وصفات الذبيحة وقياسات الدم في دجاج اللحم، حيث تم توزيع او تقسيم عدد ١٠٨ من كتاكيت اللحم نوع روس بعمر يوم واحد بشكل عشوائي على ٤ مجموعات لتحتوي كل مجموعة على ٢٧ كتكوت مقسمة الى ٣ مكررات في كل منها ٩ كتاكيت. تم إعطاء المجموعة (1) عليقة اعتيادية (مجموعة السيطرة)، و المجموعة (2) عليقة اعتيادية مضاف لها 2٪ زيوليت (مجموعة الزيوليت)، و المجموعة (3) عليقة اعتيادية مع اضافة مزيج الاحماض العضوية في مياه الشرب بنسبة 1٪ (مجموعة الاحماض العضوية) و المجموعة (4) عليقة اعتيادية مضاف لها 2٪ زيوليت مع اضافة نسبة 1٪ من مزيج الأحماض العضوية في ماء الشرب (المجموعة المشتركة). كشفت النتائج انه في فترة البادئ (٠-٣ أسابيع)، كان أفضل معامل تحويل غذائي لمجموعة الزيوليت والمجموعة المشتركة (P<0.05)، بينما في فترة النامي (٣-٦ أسابيع) كان أفضل معامل تحويل غذائي لمجموعة الأحماض العضوية والمجموعة المشتركة أيضاً مقارنة ببقية المجموعات. وبالنسبة لنتائج الفترة التجريبية كاملة (٠-٧ أسابيع)، كان تناول العلف والوزن المكتسب أفضل في مجموعتي الزيوليت والأحماض العضوية تلتهما المجموعة المشتركة ثم مجموعة السيطرة، وفي نهاية التجربة سجلت المعاملات (الزيوليت والاحماض العضوية والمجموعة المشتركة) أفضل تحويل غذائي (P<0.05) مقارنة بمجموعة السيطرة. لوحظت فروق معنوية (P<0.05)، في نسب التصافي للذبائح عند نهاية هذه التجربة، حيث حققت المجموعة المشتركة أفضل نسبة تصافي للذبيحة تلتها مجموعة الزيوليت ثم مجموعة الأحماض العضوية ثم مجموعة السيطرة. وفيما يتعلق بوزن القلب والكبد والطحال والقانصة والمعدة الغدية فقد سجلت مجموعة الأحماض العضوية أعلى الاوزان تلتها مجموعتي الزيوليت والمجموعة المشتركة ثم مجموعة السيطرة. كما كشفت النتائج ايضا ان البروتين الكلي في مجموعتي (الزيوليت والاحماض العضوية والمجموعة المشتركة) كانت أعلى بكثير عن مجموعة السيطرة، بينما انخفضت نسبة الكوليسترول والدهون الثلاثية، اليوريا والكرياتينين في الدم في المجموعات المعالجة بشكل ملحوظ عن مجموعة السيطرة. نستنتج من هذه الدراسة أن اضافة الزيوليت بالاكل والأحماض العضوية في الماء إما بمفردها أو مجتمعة كان له تأثير كبير على أداء دجاج اللحم وصفات الذبيحة وقياسات الدم، وعليه يمكن استخدام هذه الإضافات بكفاءة في العلائق الغذائية للدواجن.

الكلمات المفتاحية: دجاج اللحم، الذبيحة، قياسات الدم، الاحماض العضوية، الزيوليت

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