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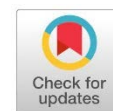
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Research Article

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Evaluation of Apparent Metabolizable Energy of Five Oil Sources in Broiler Chickens

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Abstract: Digestibility trial was conducted to evaluate the apparent metabolizable energy (AME) of crude palm oil (CPO), soybean oil (SO), crude palm fruit oil (CPFO), RBD palm olein (RBDPO) and RBD palm olein + lecithin were evaluated. A total of 100, 1-day old broiler chicks were purchased from local hatchery. On day 21, birds with similar body weight were picked randomly and distributed to experimental units with three birds per unit (cage) and five replicates per unit were randomly distributed. The birds fed for eight days with five test diets containing different oil sources (CPO, SO, CPFO, RBDPO and RBDPO+L), that were developed by replacing 60g/kg of the basal diet and corn-soy basal diet. The findings showed that there were no significant different ($P>0.05$) among the treatment in apparent metabolizable energy for the different oils.

Keywords: Apparent metabolizable energy; broiler chicken; digestibility; palm fruit oil.

تقييم الطاقة الأيضية الظاهرة لخمس مصادر زيتية في الدجاج اللحم
المستخلص: تم إجراء تجربة الهضم لتقييم الطاقة الأيضية الواضحة (AME) لزيت النخيل الخام (CPO)، وزيت فول الصويا (SO)، وزيت ثمار النخيل الخام (CPFO)، وأولين النخيل RBD (RBDPO) وأولين النخيل RBD + الليسيثين. تم شراء عدد 100 فريخ لاجد م عمر يوم واحد من المفرخ المحلي. في اليوم 21، تم اختيار الطيور ذات الوزن المماثل عشوائياً ووزعت على الوحدات التجريبية بواقع ثلاثة طيور لكل وحدة (قفص) وخمس مكدرات لكل وحدة تم توزيعها عشوائياً. تم تغذية الطيور لمدة ثمانية أيام بخمس أنظمة غذائية اختبارية تحتوي على مصادر زيتية مختلفة (CPO، وSO، وCPFO، وRBDPO، وRBDPO+L)، والتي تم تطويرها عن طريق استبدال 60 جم/كجم من النظام الغذائي الأساسي والنظام الغذائي الأساسي للذرة وفول الصويا. أظهرت النتائج عدم وجود اختلاف معنوي ($P>0.05$) بين المعاملات في الطاقة الأيضية الواضحة للزيوت المختلفة.

الكلمات المفتاحية: طاقة واضحة قابلة للاستقلاب؛ الدجاج اللحم؛ الهضم؛ زيت ثمار النخيل.

INTRODUCTION

Vegetable oils and animal fats are used in poultry diets to enhance energy concentration and to boost productivity (Lopez-Bote et al., 1997). Because of their high apparent metabolizable energy (AME), the (AME) content in oils is thrice higher than the other source of energy which is used in poultry diet (Mateos & Sell, 1981). Feeding cost account about 65% of total production



cost, dietary oils maybe can help industry to produce meat at a reasonably price by improve the growth performance and meat yield (Corzo et al., 2005).

The supplement of oil in checks diet, in addition of being the main source of energy, also enhance the absorption of fat-soluble vitamin, decrease the pulverulence, elevate the palatability of the diet and increase the adequacy of the consumed energy. Moreover, it reduces the passage rate of the food that is under digestion in the gastrointestinal tract, that permits a well absorption of all nutrients present in the diet (Ayed et al., 2015; Baião & Lara, 2005). Soybean oil and palm fruit oil are commonly used in feed factory.

While former findings have shown the influence of complementing different kinds of oils on growth performance, apparent metabolizable energy (AME) and metabolism of fats in broiler chicken, the information are still not reliable. Because of that, Tancharoenrat et al. (2013) observed that the birds consuming tallow has a significantly higher percentage of apparent metabolizable energy compared with birds consumed soybean oil, palm fruit oil and poultry fat. Abdulla et al. (2016) found that there were no significant difference in apparent metabolizable energy between birds consuming palm fruit oil, linseed oil and soybean oil despite they are different in their fatty acid profile. In addition, most available data on the AME of different source of oil which used in broiler diets are very old (25 to 50 years ago) and most of the studies were conducted using slow growing strains of broiler chickens, not only have broiler strains changed the oils source also changed in their (composition and quality) Thus, the current study was aimed at assessing the AME in different source of oils: Crude Palm oil (CPO), Soybean oil (SO), RBD Palm olein (RBD PO), Crud Palm Fruit oil (CPF) and RBD Palm olein + 2% lecithin when fed to broiler chicks.

MATERIALS AND METHODS

Birds, husbandry and experimental procedure

A total of 100 one-day old Cobb500 broiler chicks were purchased from a commercial hatchary. The starter diet (22% crude protien) were offerd from one day old until day 21. The birds were raised in open-sided house under the tropical conditions at the Research station in Universiti Putra malaysia. The birds were given feed and water ad-libitum. All birds were vaccinated with ND-IB live vaccine (May Vac, Kuala Lumpur, Malaysia) against infectious bronchitis and Newcastle Disease on day 4, IBD vaccine (May Vac, Kuala Lumpur, Malaysia) against infectious bursal disease on day 7 and ND -IB live vaccine against infectious bronchitis and Newcastle diseases on day 21 through eye drops. On day 21 birds with similar body weight were picked randomly and distributed to experimental units; 3 birds per unit (cage) and five replicates per treatment were distributed randomly to a basal diet and each of the five test diets: Crude palm oil CPO ; Soybean oil SO; Crude palm fruit oil CPFO; RBD palm olein; RBD Palm olein + lecithin 2% (E8000-S2). The composition of Fatty Acid (% of Total Identified Fatty Acid) is shown in Table 1. For the measurement of AME test the classic total extra method was used. The birds were fed in mash form for a periode of eight days, with first four days as an adaptation period. During the last four days, feed intake (FI) of each unit were recorded, and the chicks' feces were collect on daily basis, collected and weighted within a cage. The collected feces was mixed thoroughly sub-sample and freeze-dried (Model 0610, Cud-don Engineering, Blenheim, New Zealand). Dried excreta sample were crushed to pass through a 0.5 mm sieve and stored in airtight plastic containers at -4°C for further analyses. Dry matter (DM) and gross energy (GE) of the diet and excreta samples were analyzed at the laboratories of Universiti Putra Malaysia.

Apparent metabolizable energy assay

The AME of CPO, CPFO, RBD PO and RBD PO+2%L and SO were determined based on the method of Horwitz. W and Latimer (2000). Official Methods of Analysis of AOAC International, Gaithersburg MA, USA. Association of Official Analytical Chemist. (Nalle et al., 2011). In this method, corn-soybean basal diet was formulated (Table 2) and the test diets, each containing different oil samples, were developed by replacing (w/w) 60 g/kg of the basal diet with different oil. The DM was determined using standard procedures (Horwitz. W & Latimer, 2000).

Before oven drying, the samples were weighted and placed in an oven dryer for 24 hours at a temperature of 105° C and after half an hour cooling in a desiccator the weights were recorded again. An adiabatic bomb calorimeter (Gallenkamp Autobomb, Uk) standardised with benzoic acid was used to determine the GE.

The AME for both the basal and test diet (different oils) was calculated based on Ravindran et al. (2014) using the following formula:

$$\text{AME of diet (kcal/kg)} = [(FI \times GE \text{ diet}) - (\text{Excreta output} \times GE \text{ excreta})] \div FI$$

$$\text{AME of the oil (kcal/kg)} = [(\text{AME of test diet}) - (\text{AME of basal diet} \times 0.95)] \div 0.06.$$

Table:(1). The composition of fatty Acid (% of total identified fatty acid) of different oils.

Fatty Acid	Crude Palm Oil	Soybean oil	Crude Palm Fruit oil	RBD Palm olein	RBD Palm olein + lecithin
C6					
C8			0.3		
C10	0.2		0.7		
C12	0.2		3.8	0.1	0.2
C14	1		2.1	0.9	1
C15	0.1		0.1		0.1
C16	45.7	10.84	39.7	40.3	42
C16:1			0.2	0.2	0.2
C17	0.2		0.2	0.1	0.2
C18	4.2	3.84	4	3.9	4.2
C18:1	37.2	23.18	38	40.6	40.1
C18:2	10.2	53.92	10.6	12.8	11.3
C20	0.3	0.38	0.4	0.4	0.4
Total Fat	99.3	92.2	99.8	99.3	99.5

Table:(2). Composition of the basal diets (as fed basis) used in the AME digestibility assays.

Ingredients (%)	AME Assay ¹
corn	64.51
Soybean meal	31.27
MDCP 21%	1.35
Calcium carbonate	1.55
Salt	0.30
L-Lysine	0.30
DL-Methionine	0.20
Anti-Oxidant	0.02
Vitamin mix	0.10
Mineral mix	0.15
Choline chloride	0.10
Toxin binder	0.15
Total, kg	100
Calculated analysis	
ME Kcal/Kg	2966.00
Protein (%)	19.00

¹Test diets were prepared by replacing 60g/kg of the basal diet with Crude palm fruit oil, Soybean oil, Crude palm fruit oil, RBD palm olein, RBD Palm olein + lecithin 2% (E8000-S2).

Statistical analysis

Data were analyzed by one-way Analysis of variance (ANOVA) using the general linear Model (GLM) procedure of the statistical Analysis System (SAS, 9.4). The Alpha level used for assessment of significance for all the analyses was set at 0.05.

RESULTS

The apparent metabolizable energy of different source of oil in broiler chicken is summarized in Table 3. The result showed that there was no significant difference ($P>0.05$) in AME between CPO (8111 Kcal/kg), SO (8365 Kcal/kg), CPFO (8232 Kcal/kg), RBD PO (8179 Kcal/kg) and RBD PO+2%L (8020 Kcal/kg). There was no significant different ($p>0.05$) in AME among the treatments.

Table:(3). AME of different sources of oil in broiler chicken.

Parameters	oil sources					SEM±
	CPO	SO	CPFO	RBD	RBD+L	
AME (kcal/kg)	8111.3	8365.5	8231.7	8179.4	8020.1	86.766

CPO: 6% Crude palm fruit oil in diet, SO: 6% soybean oil in diet, CPFO: 6% Crude palm fruit oil, RBD: 6% Refine, Bleached and Deodorized palm olein oil, RBD+L: 6% Refine, Bleached and Deodorized palm olein oil + 2 % lecithin in diet.

DISCUSSION

The AME values in oils is influenced by its chemical structure (Freeman, 1984; Krogdahl, 1985). Number and position of double bonds of fatty acids, presence and absence of ester bonds (triglycerides or free fatty acids), carbon chain length, the amount and type of triglycerides, the composition of free fatty acid, glycerol backbone SFA and USFA arrangement, sex, age and the intestinal flora of birds (Baião & Lara, 2005). In this study the AME in CPO, CPFO, RBD PO and RBD PO+2%L was similar to SO, however CPO, CPFO, RBD PO and RBD PO+2%L had a higher ratio of USFA to SFA compared to SO. The AME similarity of the CPO, CPFO, RBD PO and RBD PO+2%L and SO could be due to the stearic acid (C18:0) low concentration in the oils. Lipase activity will be stop due to stearic acid presence (van Kuiken & Behnke, 1994).

Therefore, stearic acid similar concentration in oils may have similar effects on lipase activity, and the result is similar AME. This report is agreeing with the reports of Tancharoenrat et al. (2013), who reported that the AME of PO was similar to that of SO. However, this result is in conflicts with findings of Kavouridou et al. (2008), who reported that there was no significant difference in AME between birds fed a diet supplemented with LO and SO but LO had significantly higher AME compared with birds fed diet supplemented with PO.

CONCLUSION

The present research show that the AME of CPO, CPFO, RBD PO and RBD PO+2%L and SO in broiler chickens was similar even with differences in the fatty acid profile of the oils.

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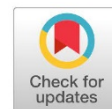
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Research Article

Open Access



Clinical Changes Evaluations in Amphotericin B Induced Osteoarthritis in Canine Models

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Abstract: The experimental model of osteoarthritis (OA) was replicated in Six dogs induced osteoarthritis by intra-articular injection with amphotericin B (AB) in the left stifle joints. Right joints served as control. Medical status and certain goniometric parameters were tracked prior to the initiation of AB and on the 30th, 60th and 90th days after injection. The findings showed compellingly that the OA model used by the experimental chemical effectively replicated the disease in the stifle joints in dogs and showed a progressive disease progression, just as it does in the reported cases of arthritis that naturally affects dogs depending on the time of inflammation. Medical indications studied were associated with the seriousness of the disease.

Keywords: Dogs, Stifle joint, Amphotericin B, Osteoarthritis, Canine Models.

تقييم التغيرات السريرية في التهاب المفاصل العظمي الناجم عن الأمفوتيريسين ب في نماذج الكلاب

المستخلص: تم تكرار النموذج التجريبي لالتهاب المفاصل العظمي (OA) في ستة كلاب من التهاب المفاصل العظمي الناجم عن الحقن داخل المفصل مع الأمفوتيريسين (AB) في مفصل الركبة اليسرى. كانت المفاصل اليمنى بمثابة السيطرة. تم تتبع الحالة الطبية وبعض المعلمات الهندسية قبل بدء AB وفي الأيام الثلاثين والستين والتسعين بعد الحقن. أظهرت النتائج بشكل مقنع أن نموذج الزراعة العضوية الذي استخدمته المادة الكيميائية التجريبية كرر المرض بشكل فعال في المفاصل الخانقة لدى الكلاب وأظهر تطوراً تدريجياً للمرض، تماماً كما هو الحال في حالات التهاب المفاصل المبلغ عنها والتي تؤثر بشكل طبيعي على الكلاب اعتماداً على وقت الإصابة بالتهاب. وارتبطت المؤشرات الطبية المدروسة بخطورة المرض.

الكلمات المفتاحية: الكلاب، مفصل الركبة، الأمفوتيريسين ب، هشاشة العظام، نماذج الكلاب.

INTRODUCTION

Osteoarthritis (OA) is a serious and chronic disease of movable joints in domestic dogs. (Johnson et al., 2016; Kraus et al., 2015) The prevalence of canine OA in the adult dog population is around 20 % to 30 %. (Muir et al., 2004). Osteoarthritis is characterized by various changes in the metabolism of joint tissue, degradation of cartilage, modified bone remodeling, formation of osteophytes, inflammation of the joint and loss of normal joint function. (Clements et al., 2006; Kraus et al., 2015).

The clinical signs of naturally occurring canine OA include, for example, reduced pain-free range of motion in affected synovial joints, reduced muscle flexibility, modified limb weight-



bearing during standing or moving, reduced performance level in daily living activities such as running, walking, rising, climbing, and gradual changes in the behavior of dogs e.g. various social contexts (Hyytiäinen, 2015; Wiseman et al., 2001).

However, pain and disability do not always correlate with structural joint changes detected by radiography, i.e. in joint space narrowing, osteophyte formation, bone sclerosis and bone cysts, pathological bone contour alterations and joint malalignment (Gordon et al., 2003; Kraus et al., 2015; Lascelles et al., 2012).

Several assessment steps should be introduced to cover the full range of pain sensitivity and the health status of osteoarthritic dogs. Quantitative sensory assessment methods have been used to examine neuronal changes in dogs with OA-related pain. (Knazovicky et al., 2017; Williams et al., 2014).

Assessment methods based on the structure and function of the body, e.g. joint range of motion, should preferably be used in combination with valid activity and performance measures, e.g. functional test batteries and quality of life associated with health (Stokes, 2010).

Pain is the most common sensory and emotional uncomfortable experience in dogs, and the inability of dogs to communicate their experience in words makes it difficult to use self-reporting methods to specifically measure pain (Mathews et al., 2014).

The choice of the measurement method needs to be focused on a specifically defined variable for clinical practice and study. That is, we have to know what to measure first. In addition, how the variable is evaluated is referred to an evaluation process. Psychometric examination includes determining the characteristics of the assessment, i.e. the validity, reliability and responsiveness of an evaluation system (Mokkink et al., 2010).

Amphotericin B intraarticular injection has an immediate toxic effect on chondrocytes, led to the development of osteoarthritis in the joint anesthetic (Fahmy et al., 1994). Symptoms of lysosomal disruption and release of inflammatory mediators resulting in joint inflammation, capsulitis and synovitis (Fahmy et al., 1994). Amphotericin has several advantages in that it generates moderate intensity of lameness, is transient in nature with limited articular changes, avoids significant systemic side effects and causes arthritis (Marttinen et al., 2006).

The aim of this study was to attempt to reproduce experimentally stifle osteoarthritis in dogs intra articular. with administration of amphotericin B to determine the model's performance or failure through gait and pain analyses.

MATERIALS AND METHODS

Experimental animals:

Six clinically healthy mongrel dogs from both sexes were used (body weight 15 ± 2 kg). They were housed indoor in individual boxes and had free access to drinking water and dry canine food for maintenance.

Experimental induction of arthritis:

Amphotericin B preparation:

Amphotericin B (Photericin B, CIPLA LTD., Verna industrial estate; India) was prepared under strict aseptic preparation with a concentration of 10 mg / ml by adding directly into the lyophilized

cake a 5 ml sterile distilled water using a 20-gage sterile needle with a syringe. The vial was well and immediately shaken until there was clear colloidal solution.

The clinical evaluation and goniometric analysis:

Three clinical scoring systems, according to Budsberg et al. (1999); Cross et al. (1997); Grisneaux. Emmanuelle et al. (1999), Used typically for drugs Effectiveness assessment of therapy was used in particular, For study of gait, behavior and pain (Tables 1, 2, 3).

The thigh circumference (TC), the stifle joint circumference (SC) and the range of motion of the stifle joint (ROM) between full flexion and extension were measured in all dogs (Ashraf. abdel-hamed. Hegazi & Khaled. M. A. Hussin, 2008; Millis & Levine, 1997) with goniometer and a band. The animals were in lateral recumbency, with the studied limb on the top.

The thigh circumference was determined in the middle of the thigh, the stifle joint circumference in 90° flexion, ROM was measured between the longitudinal axes of the femur through trochanter major and the tibia through maleolus lateralis.

Table: (1). Criteria for pain and behaviour evaluation of dogs with osteoarthritis.

Parameter	Score	Clinical sign
Behaviour	1	Apathetic or indifferent
	2	Friendly
	3	Nervous, submissive behaviour
	4	Very nervous, tries to move away
	5	Aggressive
Compliance with restraint	0	No objection
	1	Recognizes manipulations, no complaint
	2	Objects but does not try to bite
Heart rate	3	Tries to bites and struggles
	0	0 to 10% greater than normal
	1	11 to 30% greater than normal
	2	31 to 50% greater than normal
	3	>50% greater than normal
Respiratory rate	0	Normal
	1	Mild abdominal assistance
	2	Marked abdominal assistance
Vocalization	0	No crying
	1	Crying but responds to calm voice
	2	Crying but does not respond to calm voice
Agitation	0	Asleep or calm
	1	Mild agitation
	2	Moderate agitation
	3	Severe agitation
Response to manipulation	0	No response
	1	Minimal response
	2	Turns head toward site, slight vocalization
	3	Turns head to bite, howls

Table: (2). Kinetic gait analysis system for clinical evaluation of lameness, pain and joint effusion of knee osteoarthritis in dogs.

Parameter	Score	Clinical sign
Standing lameness	1	Normal weight-bearing
	2	Partial weight-bearing
	3	Intermittent toe touching
	4	No weight-bearing
Trotting lameness	1	Normal weight-bearing
	2	Marked lameness with partial weight-bearing
	3	Marked lameness with intermittent toe touching
	4	No weight-bearing
Pain re-sponse	1	Absence of pain and response
	2	Slight pain, allowing manipulations of the limb within the normal range of motility, manifested by turning the head and pulling the limb away
	3	Moderate pain, not allowing manipulations of the limb within the normal range of motility, manifested as described for score 2
	4	Significant pain, not allowing manipulations of the limb Joint
effusion	1	Normal – palpatory compression upon the patellar ligament
	2	Weak – slight increase, the patellar ligament is palpated
	3	Moderate – marked increase, slightly perceptible ligament
	4	Significant – the patellar ligament is not palpated

(Cross et al., 1997).

Table: (3). Scoring system for evaluation of hindlimb use in dogs with OA.

Parameter	Score	Clinical sign
Lameness	1	Stands and walks normally
	2	Stands normally, slightly lame at walk
	3	Stands normally, severely lame at walk
	4	Abnormal stance, slightly lame at walk
	5	Abnormal stance, severely lame at walk
Weightbearing	1	Normal at both rest and walk
	2	Normal at rest, favours affected limb at walk
	3	Partial at both rest and walk
	4	Partial at rest, no weightbearing at walk
	5	No weightbearing at rest and walk
Response to contralateral limb lift*	1	Accepts displaced weight
	2	Mild resistance to displaced weight
	3	Moderate resistance to displaced weight**
	4	Strong resistance to displaced weight***
	5	Refusal to lift the contralateral limb
Response to affected limb extension	1	No response
	2	Mild response (turning head toward the affected limb)
	3	Moderate response (withdrawal of affected limb)
	4	Severe response (vocalization, aggression)
	5	Disallows manipulation or palpation of affected limb

* response of the affected hind limb; ** replacement of the contralateral limb in < 10 s *** replacement of the contralateral limb in < 5.
(Budsberg et al., 1999).

All results were compared to the contralateral joint.

Statistical analysis:

The results were statistically processed by the non-parametric Friedman and Mann-Whitney tests using statistical software (Statmost for Windows, Datamost Corp). Differences were accepted as statistically significant at $p < 0.05$. Relationships between parameters were estimated by the Pearson correlation analysis test.

RESULTS

The average Grisneaux's score increased statistically significantly at $p < 0.01$ from 6 ± 1 points in the beginning of the experiment to 14 ± 2 (day 30) and 12 ± 2 (day 60) (Table 4).

The respective score according to Cross et al. yielded 4 ± 0 points (day 0), 13 ± 1 (day 30), 12 ± 1 (day 60) and 9 ± 1 (day 90) ($p < 0.01$ vs baseline). Average Budsberg score before the first AB administration was 4 ± 0 with considerable increase by day 30 to 17 ± 1 , followed by reduction to 13 ± 1 and 11 ± 1 by days 60 and 10 $\pm$ 5, respectively ($p < 0.01$ vs day 0).

Goniometric analysis provided evidence for thigh muscles atrophy of the left hind limb (Table 4) as thigh circumference decreased significantly from 32 ± 1 cm in the beginning to 23 ± 1 cm by the 90th day ($p < 0.01$). The values between left and right limb was also statistically significantly different ($p < 0.05$ by days 30 and 60 and $p < 0.01$ by day 90). The stifle joint circumference did not show significant differences with time. The range of motion (ROM) of left joints decreased

considerably from 115 ± 2 in the beginning to 95 ± 7 , 91 ± 2 , and 83 ± 4 by days 30, 60 and 90, respectively ($p < 0.01$). ROM of the left joint exhibited a negative correlation with clinical.

Table: (4). Clinical scores and goniometric parameters in dogs with experimental (AB) model of stifle joint osteoarthritis (mean + SEM; n=6).

Parameter		Days after first AB injection			
		0	30	60	90
Grisneaux' score		6 ± 1	$14 \pm 2^{**}$	$12 \pm 2^{**}$	11 ± 3
Cross' score		4 ± 0	$13 \pm 1^{**}$	$12 \pm 1^{**}$	$9 \pm 1^{**}$
Budsberg' score		4 ± 0	$17 \pm 1^{**}$	$13 \pm 1^{**}$	$11 \pm 1^{**}$
Thigh circumference, (cm)	left	32 ± 1	$27 \pm 1^*$	$27 \pm 1^{**}$	$23 \pm 1^{**}$
	right	32 ± 1	$32 \pm 1^{\#}$	$30 \pm 1^{\#}$	$30 \pm 1^{##}$
Stifle joint circumference, (cm)	left	25 ± 1	27 ± 1	26 ± 1	25 ± 1
	right	25 ± 1	23 ± 1	23 ± 1	23 ± 1
Range of motion, (o)	left	115 ± 2	$95 \pm 7^{**}$	$91 \pm 2^{**}$	$83 \pm 4^{**}$
	right	115 ± 2	111 ± 5	$113 \pm 3^{##}$	$110 \pm 4^{##}$

* $p < 0.05$; ** $p < 0.01$ vs baseline (day 0); $^{\#}p < 0.05$; $^{##}p < 0.01$ between left (OA) and right (control) joints.

DISCUSSION

This is one of the first studies proving the degree and duration of canine amphotericin B-induced synovitis arthritis. The results indicated that OA in dogs could be successfully by injecting higher doses of AB into the joints and using duplicated applications. In this study, Amphotericin-B was administered to induce arthritis. In (Kotschwar et al., 2009). used an amphotericin B-induced transient arthritic model to evaluate the effects of The amphotericin B-induced lameness paradigm has also been shown to produce a transitory synovitis arthritis that was expected and mild in degree.

They were significantly reduced in Kotschwar et al. (2009) study than it was in the equine literature, with equine studies showing moderate to severe lameness (grade 3-4/5) lasting 3 to 2 weeks (Martinen et al., 2006) Other research has found a reduction in the severity and duration of lame-

ness in cattle. Comparing with canine and equine model, indicated a little dose of AB was enough to cause a rapid decrease in rat stifle locomotor activity, and that low dosages only had a temporary impact. May be due to several reasons, including that only one injection of amphotericin B was administered as opposed to several injections in the majority of the equine and canine studies. When Amphotericin B was injected in the distal interphalangeal joint rather than one of the carpal or tarsal joints, the severity and duration of lameness may be changed. Furthermore, cattle may transmit a significant amount of weight from one claw to the other, reducing pain-related lameness in the afflicted claw (Kotschwar et al., 2009).

Similar to Bove et al. (2003) findings, larger and repeated dosages successfully replicated all signs of osteoarthritis: acute inflammation at beginning, increasing degeneration, and transition to chronic atrophic phase. They're significantly ideal for chemical OA models, including the one used in this study, because the joint instability identified after the mechanical models could be ruled out as a source of biomechanical abnormalities.

Since chondrocytes are required for cartilage structural stability, intra-articular injection of AB causes cartilage degradation and subchondral bone formation. The goniometric study that was utilized provided, this chemical model as Amphotracin B-induced osteoarthritis has an objective measure of the appearance of early joint effusion and progressing inactivity and muscle atrophy of the treated limb, combined with limited joint motility. Abnormalities that match the pathology of OA. The subchondral bone becomes exposed as the degenerative model proceeds, resulting in joint dysfunction and mechanical hypersensitivity associated with pain (Harvey & Dickenson, 2009).

The pain-related behaviour in this model is thought to be characterised by an early acute inflammatory phase resulting from a fluid expansion of the synovial membrane followed by a persistent phase where the inflammation is largely resolved and is not thought to contribute to the pain pathogenesis (Bove et al., 2003). We utilized three pain and gait rating methods in dogs to reduce the subjectivity of clinical assessment (Grisneaux et al. 1999; Cross et al., 1997, Budberg et al., 1999).

Although these methods for measuring pain have been presented, they are very useful in determining the intensity and duration of pain in addition to various parameters are included. Gardner (1994) observed that clinical symptoms in the course of OA development were regular, which was verified by the high positive correlation between individual scores. As early with the first month, the utilized goniometric analysis provided an objective assessment of the appearance of early joint effusion, progressive inactivity and muscle atrophy of the treated limb, associated with restricted joint mobility, particular for this chemical model.

CONCLUSION

Clinical evaluations, goniometric data, and the correlation between them indicated that the utilized experimental model of OA causing metabolic problems in articular cartilage had a duration course comparable to that of naturally occurring disease in dogs. Amphotericin B model was successful in producing acute synovitis during the first period of study and joint pain in addition to degenerative joint disease. This model could be useful to those studying the pathophysiology of joint disease and may be an ideal method to test the efficacy of new drugs intended for the treatment of joint disease. AB model need more investigation and studying of the

appropriate AB dose and the number of injections. The used experimental model of OA provoking metabolic disorders in articular cartilage exhibited a time course similar to that of naturally occurring disease in dogs, confirmed by clinical scores, goniometric data and the correlation between them effective method to study the disease process in dogs during the early stages of the disease.

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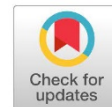
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Research Article

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Genotype-Environment Interaction and Phenotypic Stability Analysis for Grain Yield of Durum Wheat in the Misurata Region

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Abstract: The objectives of this study were to assess genotype-environment (GE) interaction and determine stable durum wheat (*Triticum turgidum* var. durum Desf.) genotypes for grain yield in Misurata in the central Libyan region. Fifteen durum wheat genotypes were evaluated under supplementary irrigation using a randomized complete block design with 3 replications. The study was repeated for 5 years. GE interaction was analyzed using linear regression techniques. There was considerable variation in grain yield among the different genotypes. Stability was estimated using the Eberhart and Russell method. According to the stability analysis, genotype G9 was the most stable for grain yield. The regression coefficient (b_i) for genotype G9 was almost one and had the lowest deviations from regressions (S^2_{di}). In contrast, genotypes G10 and G3 showed regression coefficients greater than 1.0, indicating sensitivity to environmental changes for grain yield. Among the genotypes, the highest average grain yield was obtained from genotypes G9 and G10 (3.19 and 3.65-ton ha⁻¹, respectively) across environments. Genotype G10 had the highest grain yield as well as a regression coefficient greater than one, suggesting that G10 was sensitive to changing environments and could be recommended for more favorable environments.

Keywords: Durum wheat; Grain yield; Stability; Libya.

التفاعل بين التراكيب الوراثية والبيئة وتحليل الثبات الوراثي لمحصول القمح الصلب في منطقة مصراتة

المستخلص: تهدف هذه الدراسة إلى تقييم التداخل بين التركيب الوراثي (GE)، والبيئة، وتحديد سلالات القمح الصلب (*Triticum turgidum* var. durum) المناسبة لإنتاج الحبوب في منطقة مصراتة - ليبيا. تم تقييم خمس عشرة سلالة، وصنف من القمح الصلب تحت الري التكميلي باستخدام تصميم القطاعات الكاملة العشوائية بثلاث مكررات. نفذت الدراسة لمدة 5 سنوات. وتم تحليل التداخل GE باستخدام تقنيات الانحدار الخطي. أوضحت النتائج وجود فروق معنوية عالية في صفة إنتاج الحبوب بين التراكيب الوراثية. أجري تقدير الثباتية وفقاً لتحليل الثبات باستخدام طريقة Eberhart، و Russell، كان التركيب الوراثي G9 هو الأكثر استقراراً في صفة إنتاج محصول الحبوب. معامل الانحدار للسلالة G9 كان وحدة تقريباً ($b_i = 1$) وسجل أدنى انحراف عن معامل الانحدار (S^2_{di}). في المقابل، أظهرت السلالات G10، و 3G معامل انحدار أكبر من 1.0، مما يشير إلى تأثيرهما الكبير بالتغيرات البيئية لصفة محصول الحبوب. سجل أعلى محصول للسلالات G10، و G9 - 3.65، و 3.19 طن/هكتار على التوالي متوسطاً لكل البيئات. أظهرت السلالة G10 أعلى محصول للحبوب، ومعامل انحدار أكبر من الواحد، مما يشير إلى أنها حساسة للتغير البيئي، ويمكن التوصية بها تحت ظروف الزراعة المروية.

الكلمات المفتاحية: القمح الصلب؛ محصول الحبوب؛ الثبات؛ ليبيا.



INTRODUCTION

Wheat, after barley, is the second most important cereal crop in Libya. Libya's production of wheat for the year 2018 was 138,770 tons, and the quantity imported for the same year was 1,461,816 tons, meaning that the contribution of the local production of wheat was 8.7% (FAO. 2020). During the periods from 1961-2013, wheat production in the Central and West Asia and North Africa (CWANA) region has increased from 22 to 126 million tons, mainly due to the adoption of modern wheat varieties of CIMMYT/ICARDA origin (Tadesse et al. 2019). Wheat is grown on a fairly wide range of soil conditions. Climate changes from year to year, such as rain amount and distribution, cause inconsistent yield production (Ceccarelli et al. 2010).

Information about phenotypic stability is useful for the selection of crop varieties as well as for breeding programs. Agricultural outputs, just as the livelihoods of people who rely upon them, are threatened by climate change, resulting in additional food insecurities (ORKING et al. 2008). It is important that we evaluate adaptation mechanisms to decrease these vulnerabilities (Kurukulasuriya et al. 2013). The yield production of a genotype is not necessarily the same under diverse agro-ecological conditions (Ali, Javidfar et al. 2003). Some genotypes may perform well in certain years but fail in several others. Genotype environment interactions (GE) are very important in the evaluation and selection of varieties because they reduce genotypic stability values under varied environments (Casadebaig et al. 2016; Hébert et al. 1995). The concept of stability has been defined in several ways. The Lin and Binns procedure showed the greatest deviation from the other procedures. The procedure defines stability as the deviation of a specific genotype's performance from the performance of the best-performing cultivar in an experiment. This implies that a stable cultivar is one that performs in tandem with the environment. Therefore, in most cases, a close correlation will be found between such a genotype and the environment. In other words, a genotype with an inherently high yield would be classified as stable as its yields over environments will always be close to that of the top performer over the respective environments (Purchase et al. & van Deventer, 2013). The most widely used procedure is the regression method, based on regressing the mean value of each genotype on the environmental index or marginal means of environments (Romagosa et al. 1993; Tesemma et al. 1998). A good method to measure stability has been previously proposed (Eberhart et al. 1966). The stability of varieties was defined by high mean yield and regression coefficient ($b_i = 1.0$) and deviations from regression as small as possible ($S^2_{di} = 0$). However, no stability study has been performed for durum wheat in Libya. The objectives of this study were to evaluate the grain yield of promising durum wheat genotypes in different environments and to determine their stabilities using stability parameters.

MATERIALS AND METHODS

Plant material and field condition: Fifteen durum wheat genotypes (1 cultivar (Karim) and 14 advanced lines) were introduced from the 39th International Durum Observation Nursery (ICARDA). The nursery includes genotypes that responded well when exposed to terminal drought, cold, heat, rusts, *Septoria tritici*, dryland root rots, tan spot, wheat stem sawfly, and Hessian fly (Bassi & Natchit, 2019). The experiments were designed as a randomized complete block design with 3 replications. The pedigrees and other information related to the durum wheat genotypes are given in Table 2. The experiment was performed under supplementary irrigation conditions in the five years starting in the 2015-2016 growing seasons at Misurata Agriculture Research Station – Libya Table 2. The seeds were sown using an experimental planter in 1.8 x 4 m plots consisting of 6 rows with a 25 cm row space. The seeding rates were about 200 seeds/m². The plots were fertilized with 200 kg N ha⁻¹ and 150 kg P₂O₅ ha⁻¹. Plots 2 m² in size were harvested by a combined harvester. The

yield was determined and expressed in tons per hectare. Climatic elements data at Misurata Agricultural Research Station are summarized in Table 1. All statistical analyses were performed using IWIN-DAP: An Excel Add-In offered by CIMMYT (Kehel & Thomas, 2016). Broad sense heritability (H^2) and variance components for grain yield were computed as proposed by (Akinwale et al. 2011; Arslan, 2007) using the following formula: $H^2 = Q2g / (Q2g + Q2ph + Q2gy + Q2e)$, where $Q2g$ is the genotypic variance; $Q2ph$ is the phenotypic variance; $Q2gy$ is the variance for genotypes with years; and $Q2e$ is the variance for error.

The IWIN-DAP: An Excel Add-In was used to describe genotypic stability. The stability test runs the Eberhart and Russel 1966 stability indices (regression coefficient, B , and deviation mean squares, $SD2$) and draws a scatter plot of average trait versus $SD2$. The trait values of a genotype in each year are regressed on the mean of the year. The deviation means squares measure describes the contribution of a genotype to the genotype by environment interaction (G.E). ($SD2$) is considered a stability parameter, as it is highly related to the remaining unpredictable part of the variability of a genotype across years. A genotype is stable when its deviation from regression on the environmental index is small. Differences in the genotype and year means were tested using Duncan's Multiple Range Test at a 0.05 level of probability.

Table:(1). Climatic data at Misurata Agricultural Research Station

YEAR	Mean C°	Mini C°	Max C°	Rain mm	Rainy day
2016	17.12	6.48	39.81	203.00	36.00
2017	17.06	4.73	43.50	215.00	35.00
2018	17.77	6.80	36.50	212.00	39.00
2019	16.05	6.33	38.79	233.00	57.00
2020	18.06	7.80	45.10	226.00	40.00
Average	17.21	4.73	45.10	217.80	41.40

Table:(2). Pedigrees and other information related to genotypes used in 6 environments.

Code	Pedigree	Sel. history
G1	Mrf1/Stj2//Gdr2/Mgn1/3/Bcrch1	ICD07-326-BLMSD-0AP-0T-2AP-0T-3AP-0APT-2AP-0AP-0AN-0MCH[TIMSJGAA]-0AUB[MTrJT]
G2	Ter1//Mrf1/Stj2/3/Icasyr1	ICD07-349-BLMSD-0AP-0T-4AP-0T-3AP-0APT-2AP-0AP-0AN-0MCH[TIMSJGAA]-0AUB[MTrJT]
G3	Ter1//Mrf1/Stj2/3/Icasyr1	ICD07-349-BLMSD-0AP-0T-6AP-0T-8AP-0APT-1AP-0AP-0AN-0MCH[TIMSJGAA]-0AUB[MTrJT]
G4	Mrb3/Tdicoccoides601116//IcamorTA0463/Zna4/4/Stj3//Bcr/Lks4/3/Ter3/6/Ossl1/5/tj5/5/Bicredera1/4/BezaizSHF//SD19539/Waha/3/Stj/Mrb3	ICD07-822-BLMSD-0AP-0T-5AP-0T-5AP-0APT-2AP-0AP-0AN-0MCH[TIMSJGAA]-0AUB[MTrJT]
G5	Geromtel1/IRANYT053//Mgn1/3/Ainzen1	ICD06-0048-BLMSD-0AP-6AP-0T-6AP-0T-2AP-0APT-2BR-0AP-0AN-0MCH[TIMSJGAA]-0AUB[MTrJT]
G6	Icamor-TA0471//IcamorTA0459/Arislahn10/3/Mgn1/3/Ainzen1	ICD06-0176-BLMSD-0AP-8AP-0T-3AP-0T-6AP-0APT-1BR-0AP-0AN-0MCH[TIMSJGAA]-0AUB[MTrJT]
G7	Quabrach1/4/IcamorTA0462/3/Maamouri3//Vitron/Bidra1/5/Murlagost2	ICD06-0303-BLMSD-0AP-1AP-0T-3AP-0T-4AP-0APT-1AP-0AP-0AN-0MCH[TIMSJGAA]-0AUB[MTrJT]
G8	Aghrass1/3/HFN94N8/Mrb5//Zna1/4/IcamorTA0458	ICD04-0178-BLMSD-0AP-8AP-0T-4AP-0T-1AP-0T-3AP-0T-3AP-0APT-1AP-0AP-0AN-0MCH[TIMSJGAA]-0AUB[MTrJT]
G9	Korifla/AegSpeltoidesSyr//Mrb5	ICDJMC04-032-BThL(Bulksel)-0sTh-0wTh-0sTh-1wTh-0sTh-0MCH-0MCH[MtAJDSZ]-0AUB[MMkJT]
G10	Korifla/AegSpeltoidesSyr//Lahn	ICDJMC04-031-BThL(Bulksel)-0sTh-0wTh-0sTh-10wTh-0sTh-0MCH-0MCH[MtAJDSZ]-0AUB[MMkJT]
G11	Saadi/Adnan2	ICD10-003-BLMSD-0AP-4AP-0TR-8STR-0TR-0AUB
G12	CandocrossH25/Ouasbar2//Berghouata1	ICD10-142-BLMSD-0AP-2AP-0TR-3STR-0TR-0AUB
G13	Quamal/Gbch2/3/Mrf2/NormalHamari//Bcr/Lks4/4/IcaKader2	ICD10-305-BLMSD-0AP-2AP-0TR-5STR-0TR-0AUB
G14	Maamouri3/Sebatel2	ICD09-1314-BLMSD-0AP-4AP-0AP-2AP-0TR-10STR-0TR-0AUB
G15	KARIM	Local verity

RESULTS AND DISCUSSION

Mean grain yield varied among years and ranged from 0.9-ton ha⁻¹ for 2016 to 3.9-ton ha⁻¹ for 2019 (Table 3). Estimates for pertinent variance components are given in Table 4. The Genotype Year and Rep variance were significant ($P < 0.05$). The remaining parameters were not significant for grain yield. The small 'genotype x year interaction' indicates a small effect of the years on relative productivity (Table 4).

Table:(3). The range of grain yield (ton ha⁻¹) in environments.

Code	Growing seasons	Mean	Maxi	Min	Range
Y1	2015-2016	2.95	5.07	0.97	4.10
Y2	2016-2017	2.63	3.71	1.86	1.85
Y3	2017-2018	0.93	1.24	0.48	0.76
Y4	2018-2019	3.92	4.61	3.31	1.30
Y5	2019-2020	2.87	4.34	2.22	2.12

Table:(4). Analysis of variance and variance components for grain yield among 15 durum wheat genotypes (Var).

Source	DF	Type I SS	Mean Square	F Value	Pr > F
Var	14	20.84	1.49	3.13	0.0010
REP	2	3.22	1.61	3.39	0.0401
YAER	4	86.89	21.72	45.63	<.0001
YAER*Var	56	33.15	0.59	1.24	0.2000
REP*Var	28	12.84	0.46	0.96	0.5295
REP*YAER	5	9.83	1.97	4.13	0.0026
Error	63	29.99	0.48		
Total	172	196.77			

The broad sense heritability (H %) was 74% for grain yield, indicating that grain yield has a complex character and yet not affected by a range of years (Table 5).

$$H = 0.08592 / (0.08592 + (-0.03294/5) + (0.55368/15)) * 100 = 74\%$$

Table:(5). Expected mean square of variance components.

MIVQUE (0) Estimates	
Variance Component	GW
Var (Var)	0.08592
Var (REP)	-0.0031769
Var (YAER)	0.75753
Var (YAER*Var)	-0.03294
Var (REP*Var)	-0.0035265
Var (REP*YAER)	-0.04976
Var (Error)	0.55368

The results of the combined analysis of stability are given in (Table 6). An analysis of variance for stability revealed significant differences in grain yield among genotypes and environments. This reveals not only the amount of variability that existed among environments but also the presence of genetic variability among the genotypes. The mean square for GE interaction was not significant for grain yield ($P > 0.05$), indicating that the 15 durum wheat genotypes interact semi-nary at 5 environments (Table 5 & Table 8). The mean grain yield of the 15 genotypes ranged from 2.14 t ha⁻¹ to 3.65-ton ha⁻¹, and the highest grain yield was obtained from genotypes G10 and G9 2.14, 3.65-ton ha⁻¹ respectively, and local variety Karim (G15) yield 2.14-ton ha⁻¹ (Table 6 & Table 7). It was emphasized that both linear (bi) and non-linear (S^2_{di}) components of GE in-

teractions are necessary for evaluating the stability of a genotype (Eberhart et al. 1966; Hébert et al. 1995). A regression coefficient (b_i) approximating 1.0 coupled with an $(S^2di) = 0$ indicates average stability. Regression values above 1.0 describe genotypes with higher sensitivity to environmental change and greater specificity of adaptability to high-yielding environments. A regression coefficient below 1.0 is indicative of more adaptability to environmental changes, and thus increases the specificity of adaptability to low-input environments (Carneiro et al. 2019; Eberhart et al. 1966; Hébert et al. 1995; Purchase et al. 2013).

Table:(6). Estimates of stability and adaptability parameters of grain yield (ton ha^{-1}) for 15 durum wheat genotypes at 5 environments.

code	Grain yield	(b_i)	(S^2di)	T test	P value
G1	2.42	0.92	5.26	1.491	0.157
G2	2.62	1.05	8.93	1.843	0.085
G3	2.74	1.19	14.63	2.216	0.043
G4	2.58	1.07	9.71	1.903	0.076
G5	2.18	0.89	4.60	1.408	0.180
G6	2.75	0.98	6.73	1.649	0.120
G7	2.42	0.98	6.87	1.662	0.117
G8	2.65	1.01	7.49	1.721	0.106
G9	3.19	0.99	7.01	1.676	0.115
G10	3.65	1.34	23.56	2.623	0.019
G11	2.62	0.98	6.78	1.654	0.119
G12	2.66	1.06	9.15	1.861	0.083
G13	2.76	0.92	5.31	1.497	0.155
G14	2.50	0.79	2.89	1.145	0.270
G15	2.14	0.82	3.38	1.230	0.238
Average	2.66	1.00		1.491	0.157
SD	0.37	0.14		1.843	0.085

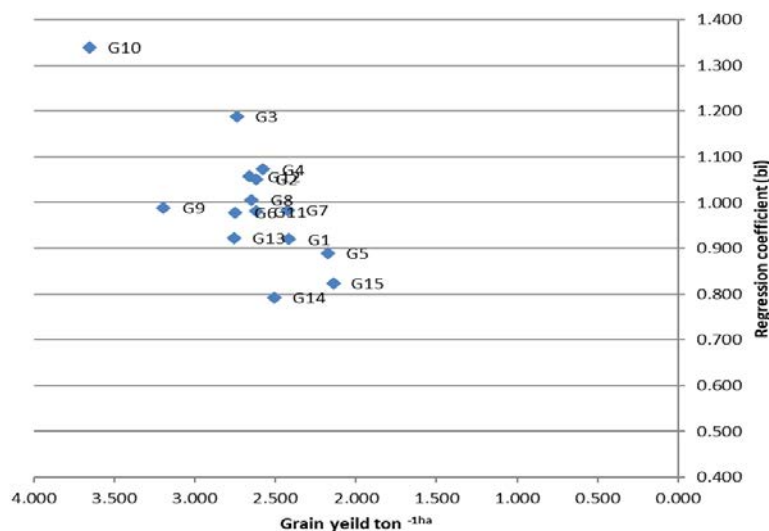


Figure:(1). The relationship between the regression coefficients and mean grain yield (ton ha^{-1}) for 15 durum wheat genotypes.

Linear regression for the average grain yield of a single genotype on the average yield of all genotypes in each environment resulted in regression coefficient values (b_i) ranging from 0.79 to 1.34 for grain yield. The great variation in regression coefficients indicates different responses of

genotypes to different years (Table 6, Figure 1). The regression coefficients of most genotypes were non-significant compared with $b_i = 1.0$ and had a small deviation from regression (S^2_{di}) and thus possessed high stability. However, genotypes G10 and G3 were significant for regression coefficient value and had a large deviation from regression (S^2_{di}), and thus possessed fair stability and sensitivity to environmental changes. Accordingly, genotype G9 (Korifla/ AegSpel-toidesSyr//Mrb5) was the most stable for grain yield because its regression coefficient was almost equal to unity, and it had lower deviations from regression. Genotype G9 had a mean yield as high as 197% compared to the local variety G15 (Karim). In contrast, genotype G10 had the highest grain yield and regression coefficients greater than one, and so was regarded as sensitive to environmental changes and can be recommended for cultivation under favorable conditions. Genotypes G1, G2, G4, G5, G6, G7, G8, G9, G11, G12, G13, G14, and G15 had insignificant regression coefficients. These genotypes could be considered widely adapted. Among these lines, genotype G9 could be considered the most stable genotype.

Table:(7). Means and Duncan's multiple range tests for grain yield (ton ha⁻¹) over 15 genotypes.

Genotype (Duncan ^{a,b,c})	N	Subset	
		1	2
G15	12	2.14 ^a	
G5	11	2.18 ^a	
G1	12	2.42 ^a	
G7	12	2.42 ^a	
G14	11	2.50 ^a	
G4	12	2.58 ^a	
G11	12	2.62 ^a	
G2	11	2.62 ^a	
G8	12	2.65 ^a	
G12	11	2.66 ^a	
G3	11	2.74 ^a	
G6	12	2.75 ^a	
G13	11	2.76 ^a	
G9	12	3.19 ^a	
G10	11		3.65 ^b
Sig.		0.050	1.000

Means for groups in homogeneous subsets are displayed.

Based on observed means.

The error term is Mean Square (Error) = .412.

a. Uses Harmonic Mean Sample Size = 11.512.

b. The group sizes are unequal. The harmonic mean of the group sizes is used. Type I error levels are not guaranteed.

c. Alpha = 0.05.

Table:(7). Means and Duncan's multiple range tests for grain yield (ton ha⁻¹) over five years in Misurata.

Growing seasons (Duncan ^{a,b,c})	N	Subset		
		1	2	3
2017-2018	39	0.93 ^a		
2016-2017	30		2.63 ^b	
2019-2020	45		2.87 ^b	
2015-2016	15		2.95 ^b	
2018-2019	44			3.92 ^c
Sig.		1.00	0.07	1.00

Means for groups in homogeneous subsets are displayed.

Based on observed means.

The error term is Mean Square (Error) = .412.

a. Uses Harmonic Mean Sample Size = 29.310.

b. The group sizes are unequal. The harmonic mean of the group sizes is used. Type I error levels are not guaranteed.

c. Alpha = 0.05.

CONCLUSION

Genotype G9 showed higher grain yields than the mean of the local variety (Karim), and its regression coefficient was close to unity ($b_i = 1.0$). This genotype was considered the best in terms of adaptation to all environments. Genotype G10 was suitable for favorable environments due to its regression coefficients being greater than unity ($b_i = 1.0$), as well as having the highest mean grain yield and low deviations from regression values ($S^2 d_i$). Most genotypes were semi-adapted because they had gone over 5 years of yield experiments. We recommend testing those genotypes in a different location and different Libyan regions.

Duality of interest: The authors declare that they have no duality of interest associated with this manuscript.

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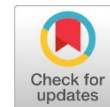
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Research Article

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The Effect of Joint Angle on Measurements of Equine Metacarpophalangeal Radiographs

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Abstract: Radiology is an important, minimally invasive, diagnostic tool used to identify and treat pathological cases. Metacarpophalangeal joint (MCPJ) radiographic parameters have been developed to evaluate equine MCPJ conformation, but the effect of MCPJ angle on these radiographic parameters has not been reported. This experiment was aimed at studying the effect of MCPJ angle on 27 (12 angular and 15 ratio) MCPJ parameters and also to determine the acceptable range at which minimal changes occurred in those parameters. Six forelimbs from six different horses with no MCPJ abnormalities or visible pathology were collected. Each MCPJ was positioned vertically and digitally radiographed dorsopalmarly at seven different MCPJ angles within the normal range and with 5.5° intervals. MCPJ angles were achieved by applying different loads using a load cell. All parameters were measured on the 42 radiographs using EponaTech Metron software. Differences were estimated per 5.5° change in MCPJ angle for all parameters. The ratio parameters were generally less affected than the angular parameters. The amount of change was small in the majority of the angular parameters and very small in all the ratio parameters. MCPJ angles ranging between 146° and 157° would be considered acceptable ranges for all these parameters.

Keywords: Equine, Metacarpophalangeal joint, Morphometry, Rotation, Radiographs.

تأثير الزاوية المشتركة على قياسات الصور الشعاعية السنية للخيول
المستخلص: يعد الطب الإشعاعي أداة تشخيصية مهمة ذات تدخل جراحي بسيط تستخدم لتحديد الحالات المرضية وعلاجها. تم تطوير المعلمات الشعاعية للمفصل السني السلامي (MCPJ) لتقييم تشكيل MCPJ للخيول، ولكن لم يتم الإبلاغ عن تأثير زاوية MCPJ على مقاييس التصوير الشعاعي هذه. هدفت هذه التجربة إلى دراسة تأثير زاوية MCPJ على 27 معلمة (12 زاوية و15 نسبة) لـ MCPJ وأيضاً تحديد المدى المقبول الذي حدث عنده الحد الأدنى من التغيرات في تلك المعلمات. تم جمع ستة أطراف أمامية من ستة خيول مختلفة مع عدم وجود تشوهات MCPJ أو أمراض مرئية. تم وضع كل MCPJ عمودياً وتصويراً إشعاعياً رقمياً ظهرانياً عند سبع زوايا MCPJ مختلفة ضمن النطاق الطبيعي وبفواصل زمنية قدرها 5.5 درجة. تم تحقيق زوايا MCPJ من خلال تطبيق أحمال مختلفة باستخدام خلية تحميل. تم قياس جميع المعلمات على الصور الشعاعية الـ 42 باستخدام برنامج EponaTech Metron. تم تقدير الاختلافات لكل تغيير قدره 5.5 درجة في زاوية MCPJ لجميع المعلمات. كانت معلمات النسبة بشكل عام أقل تأثراً من المعلمات الزاوية. كان مقدار التغيير صغيراً في غالبية المعلمات الزاوية وصغيراً جداً في جميع معلمات النسبة. تعتبر زوايا MCPJ التي تتراوح بين 146 درجة و157 درجة نطاقات مقبولة لجميع هذه المعلمات.

الكلمات المفتاحية: الخيول، المفصل السني السلامي، القياس الشكلي، الدوران، صور الأشعة السينية.



INTRODUCTION

Radiography is an important technique in the diagnosis of musculoskeletal injuries. However, in terms of the morphometrical studies, the details of the bony feature might easily be altered due to the high sensitivity of the x-ray to any movement of the radiographic tools while the radiographs are being taken. Thus, in radiographic studies, a number of factors have been investigated for improving the accuracy of measurements, such as projection errors (Curry et al., 1990; Han et al., 1994; Lavin, 2007; Oheida et al., 2016; Walter & Davies, 2001), landmark identification (Chen et al., 2004; Nagasaka, 2003) and contrast of radiographs (Chen et al., 2000; Major et al., 1994).

Unlike most of the joints in the equine body, the angle of the metacarpophalangeal joint (MCPJ) was considered an additional factor that can affect its morphometrical measurements. MCPJ is a hinge joint that is able to flex and extend on its horizontal axis (Dyce et al., 2002; Sisson & Grossman, 1975). The joint angle varies in normal horses, with a reported range of its dorsal extension between 135° and 168° (Holmstrom et al., 1990; Weller et al., 2006). This range was reported to be affected by a number of factors, such as the hoof angle (Bushe et al., 1988; Rooney, 1984) and the uneven distribution of the body weight on the limbs (Denoix et al., 1996). Although the effect of joint angles on radiographic measurements was evaluated and considered as a source of measurement errors in different fields (Lonner et al., 1996; Meijer et al., 2016; Sun et al., 2021), the influence of the MCPJ angle on its radiographic measurements was not investigated. This means that unless the possible effects of such variations in angle were precisely evaluated and understood, MCPJ measurements may have only limited application in the veterinary field.

In dorsopalmar radiographs, the radiographic measurements could be affected by moving the object around its vertical and horizontal axes (Major et al., 1996) but not around its sagittal axis (Ahlqvist et al., 1983; Yoon et al., 2002). The effect of rotation of the MCPJ around its vertical axis on the radiographic parameters has been evaluated in a recent study (Alrtib et al., 2023), but there is no information about the effect of the rotated joint around the horizontal axis. When the joint was loaded, the joint angle changed due to its dorsal extension, which occurred by moving the bones around the horizontal axis of the joint. Accordingly, any changes in radiographic measurements of MCPJ should be interpreted based on the concept of the association between landmarks of the parameters and the rotation around the horizontal axis.

The hypothesis of this study was that changes in the MCPJ angle of horses would affect its radiographic parameters. If so, then was there a limited range of joint angles at which the measurements presented the lowest level of alterations. Therefore, the current study was first aimed at identifying the potential effect of the MCPJ angle on its measurements using dorsopalmar (DP) radiographs. Secondly, to determine an acceptable range of the joint angle at which a minimal amount of change occurred on the parameters.

MATERIALS AND METHODS

Animals

Six (three right and three left) distal forelimbs of six different adult horses were used. Their ages ranged between 7 and 21 years old. The horses had a normal body conformation and were euthanized or died for reasons not associated with the locomotor apparatus. All the forelimbs were collected from the Pathology department, Department of Veterinary BioSciences, The University of Melbourne. The forelimbs were cut at the distal third of the radius.

Preparation of the forelimbs

Each forelimb was set in a load cell in order to get different MCPJ angles. The hoof of the forelimb was rested on the cell base against a V-shaped cut that was made on the Perspex plate to avoid the hoof sliding during loading. The upper part of the limb was fixed into an aluminum cup using fasteners (Figure 1).

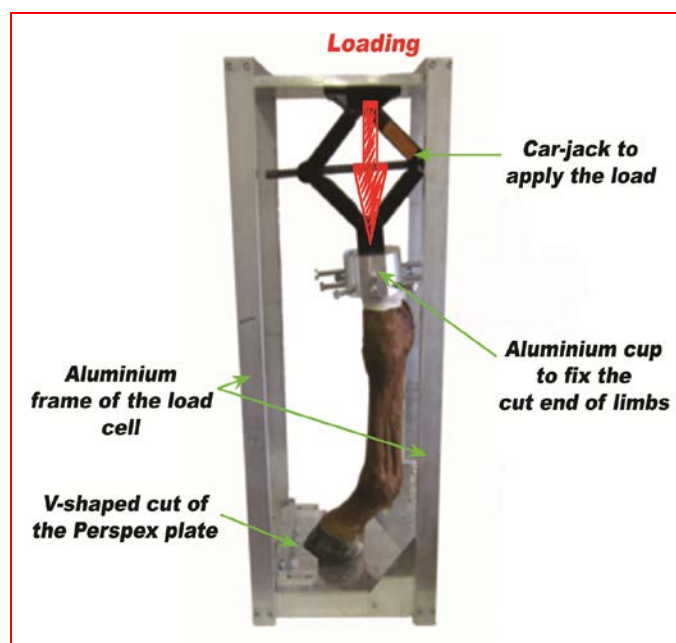


Figure: (1). Installing and loading a horse limb in the load cell.

Limb loading and MCPJ angle

The MCPJ of the installed forelimbs in the load cell were positioned at a normal angle, which ranged between 135° and 168° (Holmstrom et al., 1990; Weller et al., 2006). Each forelimb was loaded seven times to obtain the aimed MCPJ angles within the normal range (Figure 2). The angles were 135° , 140.5° , 146° , 151.5° , 157° , 162.5° , and 168° . A Prestige Medical 8-inch protractor goniometer was used to measure each of the seven MCPJ angles based on Alrtib et al. (2015).

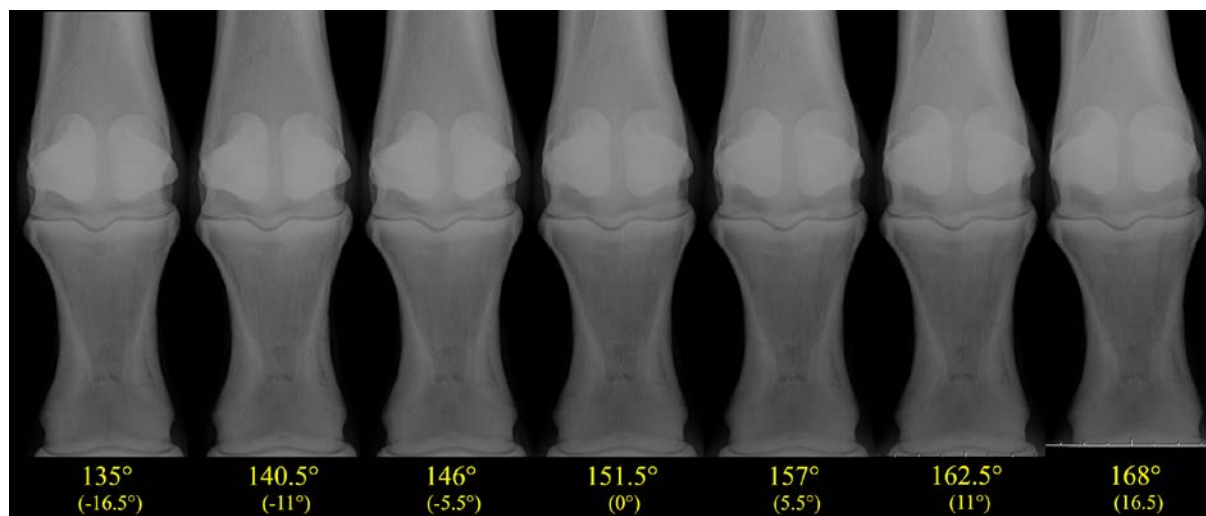


Figure: (2). Dorsopalmar radiographs of an equine metacarpophalangeal joint (MCPJ) during loading the limb. The radiographs showed the resultant changes in MCPJ morphology in seven different joint angles within the normal range.

MCPJ radiography

A fixed digital x-ray machine (Toshiba Rotanode™, Toshiba- Japan), digital cassettes (Fujifilm, Fuji IP Cassette Type CC), radiographic processor and cassette holder (Fujifilm FCR Capsula XL, CR-IR 356, Fuji Photo Film CO. LTD. Japan) were used. The dorsopalmar view of MCPJ was used. During radiographing the joint in this view, the head of the x-ray machine was faced towards MCPJ where the central beam of radiation was directed onto the dorsal surface of the joint and perpendicular to the long axis of P1. Each joint was radiographed seven times in the positions corresponding to the MCPJ angles listed previously, with an interval of 5.5°. The joint angle of 151.5° was considered as the middle angle or Zero° and hence the radiographs were labelled as 168° (–16°), 162.5° (–11.5°), 157° (–5.5°), 151.5° (Zero°), 146° (+5.5°), 140.5° (+11.5°) and 135° (+16°). All the 42 radiographs were sent to a program called Synapse (Synapse Intelligent Connectivity, Version 3.1.1, Fujifilm Medical System, U.S.A. Inc. 419 West Avenue Stamford, CT 06902). The radiographs were then collected after being labeled and recorded with their details..

Radiographic parameters and measurements

27 MCPJ parameters (12 angles and 15 ratios), which were developed by Alrtib et al. (2019), were measured.

They were:

Angular parameters:

Base medial PSB-Proximal P1 angle (B1)
 Base lateral PSB-Proximal P1 angle (B2)
 Base PSBs angle (B3)
 Lowest PSBs-Proximal P1 angle (B4)
 Highest PSBs-Proximal P1 angle (B5)
 P1 angle (B6)
 Trigonum P1 angle (B7)
 Medial trigonum-Proximal P1 angle (B8)
 Lateral trigonum-Proximal P1 angle (B9)
 Medial sagittal ridge Mc3- Proximal P1 angle (B11)
 Lateral sagittal ridge Mc3- Proximal P1 angle (B13)
 Sagittal ridge angle (B14).

Ratio parameters

Ratio of the lateromedial width of the medial articular cavity to the lateromedial width of the lateral articular cavity of P1 (W2/W3).
 Ratio of the lateromedial width of the medial sesamoid bone to the lateromedial width of the lateral sesamoid bone (W4/W5).
 Ratio of the lateromedial width of the proximal extremity of P1 to the lateromedial width of the distal extremity of Mc3 (W1/W6).
 Ratio of the lateromedial width of the medial sesamoid bone to the palmar lateromedial width of the medial condyle of Mc3 (W4/W7).
 Ratio of the lateromedial width of the medial sesamoid bone to the palmar lateromedial width of Mc3 (W4/W7+W8).
 Ratio of the lateromedial width of the lateral sesamoid bone to the palmar lateromedial width of the lateral condyle of Mc3 (W5/W8).
 Ratio of the lateromedial width of the lateral sesamoid bone to the palmar lateromedial width of the Mc3 (W5/W7+W8).
 Ratio of the palmar lateromedial width of the medial condyle to the palmar lateromedial width of the lateral condyle of Mc3 (W7/W8).

Ratio of the lateromedial width of the medial articular cavity of P1 to the palmar lateromedial width of the medial condyle of Mc3 ($W2/W7$).

Ratio of the lateromedial width of the lateral articular cavity of P1 to the palmar lateromedial width of the lateral condyle of Mc3 ($W3/W8$).

Ratio of the palmar lateromedial width of the medial condyle to the lateromedial width of the distal extremity of Mc3 ($W7/W6$).

Ratio of the palmar lateromedial width of the lateral condyle to the lateromedial width of the distal extremity of Mc3 ($W8/W6$).

Ratio of the proximodistal height of the medial sesamoid bone to the proximodistal height of the lateral sesamoid bone ($H1/H2$).

Ratio of the proximodistal height of the medial sesamoid bone to the proximodistal height of P1 ($H1/H3$).

Ratio of the proximodistal height of the lateral sesamoid bone to the proximodistal height of P1 ($H2/H3$).

Hoof-Metron measurement software (EponaTech LLC, USA) was used to measure the radiographs. In this software, a free Mark-Up utility was used to measure all the parameters. All the 27 parameters were measured on each of the 42 radiographs (7 radiographs from 6 MCPJ). To avoid the risk of errors related to fatigue, no more than eight radiographs were measured in one day. All measurements were taken by the first author.

Acceptable range of joint angle

Identifying the acceptable range of the joint angle was determined based on measuring the amount of change in the parameters between the different MCPJ angles. The joint angle of 151.5° was considered as zero° or the central angle, from which the amount of change in the values of the parameters was calculated in the other six MCPJ angles. The angle of the joint at which the parameters showed a minimum amount of change was identified and considered an acceptable range of MCPJ angle.

Statistical analysis

A mixed model with a fixed effect of MCPJ angle (centered at 151.5° degrees) and a random effect of horse was used to estimate the common slope within horse for each of the measured parameters. The percentage change for a 5.5° increase in the joint angle was calculated as $(\text{slope} \times 5.5 / \text{absolute predicted value at zero degrees}) \times 100$. The Stata (v12.0, Stata Corp, College Station, TX) command `-(xtmixed-)` was used. Statistical significance was set at $P < 0.05$. The identification of the acceptable range of the joint angle was determined based on the statistical results. Means of changes, regardless of whether they were increasing or decreasing, in the values of all the parameters were measured per 5.5° of change in MCPJ angle from the Zero° angle (151.5°).

RESULTS

Effect of MCPJ angle changes on parameters

Angular parameters

From the statistical analysis, it can be seen that the effect of the MCPJ angle was significant in B1, B2, B3, B5, B7 and B9 (Table 1).

The increase in the dorsal MCPJ angle led to a gradual increase in the values of B1 and B2 but a gradual decrease in B3. It also led to an overall increase in the values of B5, B6 and B7. The rest of the angular parameters showed fluctuations in their changing values. The greatest change was found in B3 (Figure 3) which changed by 0.72° with every 5.5° change in MCPJ angle. Conversely, B13 had the least amount of change which altered by approximately 0.002° per 5.5° of change.

Table: (1). Comparison between the values of the angular and the ratio parameters measured on the seven MCPJ angles. Six MCPJs from six different horses were used. The percentage change for a 5.5° increase in MCPJ angle was calculated as (change per 5.5°/absolute predicted value at centred zero degrees) x 100.

Parameter		135° (-16.5°)	140.5° (-11°)	146° (-5.5°)	151.5° (0°)	157° (5.5°)	162.5° (11°)	168° (16.5°)	Predicted change per 5.5°	
									Change	Percentage
									SE P-value	
B1	Mean	16.91	17.18	17.58	17.87	18.21	18.59	18.76	0.32256	1.81
	Mean Diff	-0.97	-0.70	-0.30	0.00	0.34	0.72	0.89	0.04252	
	SE Diff	0.34	0.29	0.15	0.00	0.11	0.26	0.25	< 0.001	
B2	Mean	14.65	15.12	15.69	16.00	16.48	16.79	16.96	0.39577	2.47
	Mean Diff	-1.36	-0.88	-0.31	0.00	0.48	0.79	0.96	0.03590	
	SE Diff	0.31	0.19	0.14	0.00	0.16	0.22	0.24	< 0.001	
B3	Mean	148.45	147.70	146.73	146.13	145.31	144.62	144.27	-0.71833	-0.49
	Mean Diff	2.32	1.57	0.60	0.00	-0.82	-1.51	-1.85	0.06880	
	SE Diff	0.53	0.42	0.26	0.00	0.21	0.43	0.43	< 0.001	
B4	Mean	2.37	2.34	2.67	2.45	2.62	2.27	2.27	-0.01768	-0.72
	Mean Diff	-0.08	-0.11	0.22	0.00	0.17	-0.18	-0.19	0.03948	
	SE Diff	0.40	0.37	0.28	0.00	0.17	0.25	0.35	0.65	
B5	Mean	3.13	3.07	3.01	3.34	3.61	3.75	3.80	0.14131	4.23
	Mean Diff	-0.22	-0.27	-0.34	0.00	0.26	0.40	0.45	0.03442	
	SE Diff	0.20	0.17	0.15	0.00	0.12	0.20	0.27	< 0.001	
B6	Mean	4.17	4.17	4.22	4.25	4.12	4.31	4.44	0.03571	0.84
	Mean Diff	-0.08	-0.08	-0.03	0.00	-0.13	0.06	0.19	0.01992	
	SE Diff	0.17	0.18	0.23	0.00	0.15	0.23	0.19	0.073	
B7	Mean	36.03	36.04	36.19	36.26	36.48	36.26	36.43	0.06899	0.19
	Mean Diff	-0.24	-0.23	-0.07	0.00	0.22	-0.01	0.16	0.02638	
	SE Diff	0.22	0.25	0.18	0.00	0.17	0.14	0.24	0.0090	
B8	Mean	72.25	72.23	72.36	72.14	72.22	72.69	72.37	0.04149	0.06
	Mean Diff	0.11	0.09	0.22	0.00	0.08	0.55	0.23	0.03167	
	SE Diff	0.18	0.24	0.20	0.00	0.14	0.21	0.22	0.19	
B9	Mean	71.73	71.74	71.45	71.60	71.30	71.06	71.20	-0.11048	-0.15
	Mean Diff	0.13	0.14	-0.14	0.00	-0.30	-0.54	-0.40	0.02998	
	SE Diff	0.13	0.17	0.15	0.00	0.29	0.11	0.17	< 0.001	
B11	Mean	38.85	39.19	39.17	39.01	39.12	39.07	38.87	-0.00887	-0.02
	Mean Diff	-0.16	0.18	0.16	0.00	0.10	0.06	-0.14	0.02194	
	SE Diff	0.15	0.11	0.05	0.00	0.17	0.10	0.17	0.69	
B13	Mean	37.60	37.48	37.38	37.71	37.38	37.46	37.60	-0.00179	0.00
	Mean Diff	-0.11	-0.23	-0.32	0.00	-0.33	-0.25	-0.11	0.02980	
	SE Diff	0.17	0.30	0.25	0.00	0.16	0.29	0.14	0.95	
B14	Mean	103.55	103.32	103.44	103.28	103.50	103.47	103.53	0.01065	0.01
	Mean Diff	0.27	0.05	0.16	0.00	0.22	0.19	0.25	0.03563	
	SE Diff	0.32	0.28	0.27	0.00	0.19	0.27	0.27	0.77	
W2/W3	Mean	1.14	1.13	1.13	1.14	1.13	1.12	1.12	-0.00228	-0.20
	Mean Diff	0.00	-0.01	-0.01	0.00	-0.01	-0.02	-0.01	0.00085	
	SE Diff	0.01	0.00	0.00	0.00	0.01	0.01	0.01	0.0070	
W4/W5	Mean	0.99	0.99	0.99	0.99	0.99	0.99	0.99	-0.00010	-0.01
	Mean Diff	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00029	
	SE Diff	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.74	
W1/W6	Mean	1.10	1.10	1.10	1.10	1.10	1.10	1.09	-0.00051	-0.05
	Mean Diff	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00018	
	SE Diff	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.0050	
W4/W7	Mean	0.89	0.90	0.89	0.89	0.90	0.90	0.89	0.00018	0.02
	Mean Diff	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00039	
	SE Diff	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.64	
W5/W8	Mean	0.99	0.99	0.98	0.99	0.99	0.98	0.99	-0.00004	0.00
	Mean Diff	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00052	
	SE Diff	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.94	
W4/(W7+W8)	Mean	0.47	0.47	0.47	0.47	0.47	0.47	0.47	0.00003	0.01
	Mean Diff	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00016	
	SE Diff	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.86	
W5/(W7+W8)	Mean	0.47	0.47	0.47	0.47	0.47	0.47	0.47	0.00007	0.02
	Mean Diff	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00014	
	SE Diff	0.00	0.00	0.00	0.08	0.00	0.00	0.00	0.62	

Parameter		135° (-16.5°)	140.5° (-11°)	146° (-5.5°)	151.5° (0°)	157° (5.5°)	162.5° (11°)	168° (16.5°)	Predicted change per 5.5°	
									Change SE	Percentage
W7/W8	Mean	1.10	1.09	1.09	1.10	1.10	1.09	1.09	-0.00044	
	Mean Diff	0.00	0.00	-0.01	0.00	0.00	-0.01	0.00	0.00077	-0.04
	SE Diff	0.00	0.01	0.00	0.00	0.01	0.00	0.01	0.56	
W2/W7	Mean	1.02	1.01	1.01	1.01	1.01	1.01	1.01	-0.00015	
	Mean Diff	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00048	-0.01
	SE Diff	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.75	
W3/W8	Mean	0.98	0.98	0.98	0.98	0.99	0.99	0.99	0.00147	
	Mean Diff	0.00	0.00	0.00	0.00	0.01	0.01	0.01	0.00049	0.15
	SE Diff	0.00	0.00	0.00	0.00	0.01	0.00	0.00	0.0020	
W7/W6	Mean	0.53	0.52	0.52	0.53	0.52	0.52	0.52	-0.00032	
	Mean Diff	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00022	-0.06
	SE Diff	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.14	
W8/W6	Mean	0.48	0.48	0.48	0.48	0.48	0.48	0.48	-0.00011	
	Mean Diff	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00020	-0.02
	SE Diff	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.58	
H1/H2	Mean	0.97	0.97	0.97	0.98	0.98	0.98	0.97	0.00034	
	Mean Diff	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00031	0.03
	SE Diff	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.28	
H1/H3	Mean	0.32	0.32	0.32	0.32	0.32	0.32	0.32	0.00031	
	Mean Diff	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00017	0.10
	SE Diff	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.064	
H2/H3	Mean	0.33	0.33	0.33	0.33	0.33	0.33	0.33	0.00021	
	Mean Diff	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00018	0.06
	SE Diff	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.22	

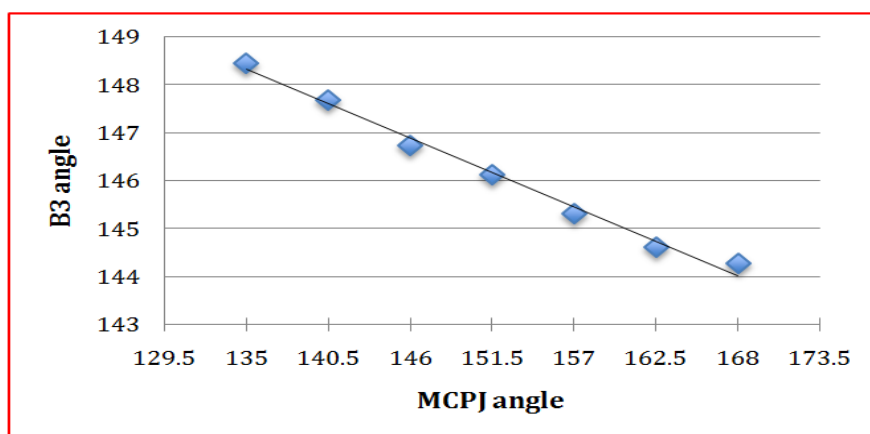


Figure: (3). Effect of changing the metacarpophalangeal jointangle on B3 parameter in 6 joints.

The minimum change was found in W4/(W7+W8) with 0.00003 units of change (Figure 4), whereas the W2/W3 ratio demonstrated the greatest amount of change with an average of 0.0023 units per 5.5° of the joint angle change.

Ratio parameters

The change in MCPJ angle had generally less effect on the ratios than on the angular parameters. The majority of the ratio parameters showed no significant effect per 5.5° change across the whole range of angles that were measured. Only three ratios were changed significantly (p values ≤ 0.01) per 5.5° change in MCPJ angle. They were W2/W3, W1/W6 and W3/W8. In all the ratio parameters, changing the joint angle by 5.5° resulted in very small changes.

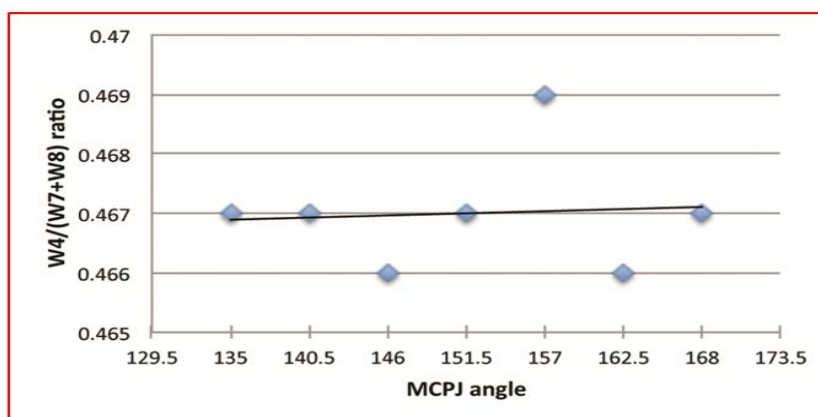


Figure: (4). Effect of changing the metacarpophalangeal joint angle on $W4/(W7+W8)$ parameter in 6 joints.

Acceptable range of MCPJ angle

The amount of change of all the parameters per 5.5° change in MCPJ angle from the centred angle is summarised in Table 2.

The changes in the joint angle by $+ \text{ or } -5.5^\circ$ demonstrated the minimal amount of change in all the parameters. The angular parameters presented an approximate change of less than 0.5° the joint angles of $\pm 5.5^\circ$ ($146^\circ - 157^\circ$) except in B3 which changed by 0.72° . At the joint angles of $\pm 11^\circ$ and $\pm 16.5^\circ$, the amount of change in all the angular parameters was less than 1° except in B2 and B3, which showed greater alteration. In the ratio parameters, the amount of change was very small at all the joint angles that were located within this normal range. The amount of change in the ratios at $\pm 5.5^\circ$ of the joint angle was less than 0.0023 units while at $\pm 11^\circ$ and $\pm 16.5^\circ$ changes were less than 0.005 and 0.007 units, respectively.

Table: (2). Means of changes per 5.5° change in MCPJ angle from the centred angle (151.5°), regardless increasing or decreasing the values, in each change in MCPJ angle for all the angular and ratio parameters.

Parameter category	Parameters	0 (151.5°)	$\pm 5.5^\circ$ ($146^\circ - 157^\circ$)	$\pm 11^\circ$ ($140.5^\circ - 162.5^\circ$)	$\pm 16.5^\circ$ ($135^\circ - 168^\circ$)
Angular parameters	B1	0	0.32256	0.64512	0.96768
	B2	0	0.39577	0.79155	1.18732
	B3	0	0.71833	1.43667	2.15500
	B4	0	0.01768	0.03536	0.05304
	B5	0	0.14131	0.28262	0.42393
	B6	0	0.03571	0.07143	0.10714
	B7	0	0.06899	0.13798	0.20697
	B8	0	0.04149	0.08298	0.12447
	B9	0	0.11048	0.22095	0.33143
	B11	0	0.00887	0.01774	0.02661
	B13	0	0.00179	0.00357	0.00536
	B14	0	0.01066	0.02131	0.03196
Ratio parameters	W2/W3	0	0.00228	0.00457	0.00685
	W4/W5	0	0.00010	0.00019	0.00029
	W1/W6	0	0.00051	0.00102	0.00153
	W4/W7	0	0.00018	0.00037	0.00055
	W5/W8	0	0.00004	0.00007	0.00011
	W4/(W7+W8)	0	0.00003	0.00006	0.00008
	W5/(W7+W8)	0	0.00007	0.00014	0.00022
	W7/W8	0	0.00044	0.00089	0.00133
	W2/W7	0	0.00015	0.00030	0.00045
	W3/W8	0	0.00147	0.00294	0.00442
	W7/W6	0	0.00032	0.00064	0.00095
	W8/W6	0	0.00011	0.00022	0.00034
	H1/H2	0	0.00034	0.00067	0.00101
	H1/H3	0	0.00031	0.00063	0.00094
	H2/H3	0	0.00022	0.00043	0.00064

DISCUSSION

The effect of changing MCPJ angles on landmarks and consequently on the values of their radiographic parameters was evaluated in this study, which found that changing MCPJ angles resulted in both significant and insignificant alterations in the measurements of most of the parameters. The majority of the significant changes occurred in the angular parameters, especially B1, B2 and B3, while the ratio parameters were generally less affected.

During extension or flexion of the MCPJ, its angle was mainly changed by moving or rotating the proximal P1 and the dorsal PSBs around the distal condyles of Mc3. This movement meant that the bones rotated around the centre of the joint motion transversely. Hence, analysing the changes in values of the parameters was based on the relationship between the landmarks and the horizontal axis of the joint on DP radiographs.

In the angular parameters, B1 and B2 angles showed a steady increase in their values when MCPJ angle was increased. This result might be associated with the tension that would have been applied through the suspensory (interosseous medius muscle) ligament and the distal sesamoidean ligaments during joint movement. The suspensory ligament originates from the distal carpal row and the adjacent area of the proximal Mc3 and runs distally on the palmar surface of the metacarpus. At the distal third or fourth of Mc3, it divides into two parts, which then insert on the abaxial surfaces of the PSBs (Dyce et al., 2002). The distal sesamoidean ligaments are three ligaments (straight, oblique and cruciate) originating from the base of the PSBs. The straight ligament inserts on the middle phalanx (P2), while the other two ligaments insert on the palmar surface of P1 (Dyce et al., 2002; Sisson & Grossman, 1975). The distal sesamoidean ligaments act against the pulling of the suspensory ligament (Pasquini & Spurgeon, 1989). So, when the loading decreased on MCPJ and its angle changed towards 168°, the tension on the ligaments would have started to be relieved, resulting in a gradual alteration in the level of the basilar borders of the PSBs. This probably occurred due to the pulling of the abaxial end (distal end of the abaxial surface) of the PSBs proximally by the suspensory ligament. While, when the loading increased and the MCPJ angle became smaller, the tension would be increased on the ligaments at which time the distal sesamoidean ligaments would have prevented the abaxial edges of the PSBs from being pulled proximally by the action of the suspensory ligament. Therefore, shifting the abaxial edges proximally and distally seemed to cause an increase and decrease in the values of the two parameters, respectively. B3, which was the most affected parameter, showed a steady and significant alteration during changes in the joint angle. However, contrary to B1 and B2, the value of B3 was increased when the MCPJ angle was decreased and vice versa. The parameter was established as an angle formed between the basilar surfaces of the medial and lateral PSBs (Alrtib et al., 2019). Hence, it can be suggested that when the joint angle increased by reducing the load, the abaxial ends of the two PSBs were pulled proximally by the suspensory ligament, leading to a decrease in the angle of the parameter.

In comparison to the angular parameters, the ratio parameters were generally less affected by changing the joint angle. Six of the fifteen ratio parameters did not change at any of the joint angles. This was in addition to two more ratios that had a very small change in only one joint angle, W1/W6 at 168° and W2/W7 at 135°. The result was not unexpected, based on two possible reasons. Firstly, the size of the ratios was relatively small, and thus any change in their values would be very small or even effectively zero. The value of W4/(W7+W8), for instance, stayed at 0.47 units in each of the joint angles, although it did change by 0.00003 unit per 5.5°. Such a tiny amount of change which was the smallest change in the study, was too small to show up in the presented values. Secondly, since the majority of the linear landmarks were measured lateromedially (horizontally), changing the joint angle due to moving the bones around the joint's horizontal axis would have little influence on the ratios. This was in agreement with many morphometrical studies that reported

that horizontally measured parameters would not be affected during the rotation of the object around its horizontal axis (Ahlqvist et al., 1986; Malkoc et al., 2005; Oheida et al., 2017).

There were twelve (6 angular and 6 ratio) parameters that showed irregular patterns of changes in their values with the different MCPJ angles. The fluctuating pattern would presumably be an indication of landmark identification errors. This type of error was correlated to a number of factors such as the nature of the landmark anatomical details (Gravely & Benzies, 1974), inter-landmark distance (Chen et al., 2004), investigator experience (Major et al., 1994) and radiographic technique (Turner & Weerakone, 2001). The likely source of errors in the current study seemed to be associated with the nature of the landmarks and the inter-landmark distance. The features of interest in B11, B13 and B14, for example, were the sagittal ridge of Mc3 and proximal P1. This ridge had small medial and lateral sides that were located adjacent to each other. If a little mistake occurred while locating such small and closely positioned landmarks, inconsistencies would easily occur in their measurements. Furthermore, in both W4/W7 and W5/W8 ratios, the landmarks were on the PSBs, which were located palmar to the condyles of Mc3. Radiographically, there was a superimposition between the PSBs and Mc3 that probably caused some difficulties in locating the landmarks on the radiographs, leading to inconsistency in the measurements. Despite the possible errors in the measurements of these parameters, their amounts of change were very small and reasonably applicable for diagnostic and morphometrical purposes. However, if such measurements are required for the clinical interference, more caution should be taken.

The second aim of the study was to identify the range of MCPJ angles at which the parameters expressed a minimal amount of change. According to cephalometric studies (Gregston et al., 2004; Kumar et al., 2008), measurement differences of 2° in angular parameters and 2 mm in linear parameters were considered to be a potential threshold for clinically meaningful differences. In addition, in an equine carpal study, it was found that the carpal rotation around its horizontal axis would result in a changing mean of less than 1° in the angular parameters per 5° of rotation, and thus $\pm 5^\circ$ was considered an acceptable range of rotation (Oheida et al., 2017). The current findings showed that changes in MCPJ angle by $\pm 5.5^\circ$ from 151.5° (146° and 157°) resulted in the minimum amount of changes in all the parameters. At these joint angles, the changes in angular measurements ranged between 0.0018° and 0.72° , whereas in the ratio parameters, the range was between 0.00003 and 0.0023 units. Hence, MCPJ angles that ranged between 146° and 157° can be assumed to be within an acceptable range of the joint angle. However, depending on the total changes that are shown in Table 2, this acceptable range could be widened to include not only the angles between 140.5° and 162.5° ($\pm 11^\circ$) but also the angles between 135° - 168° ($\pm 16.5^\circ$), but with considering the possible larger changes in B2 and B3. Using the acceptable range of MCPJ angle would be applicable as long as the joint was not rotated around its vertical axis, which was reported to have a potential effect on the measurements (Alrtib et al., 2023). If so, then more investigations should be performed to include the effect of the joint angle and the vertical axis on MCPJ parameters.

CONCLUSION

In conclusion, changing the MCPJ angle affected the radiographic measurements in most of the parameters. The angular parameters showed more significant changes than the ratio parameters. Larger changes were found in the significantly influenced parameters. The irregular pattern of changes in some parameters seemed to be related to a number of factors, such as the nature of the landmarks and the superimposition of bones. The range of 146° to 157° of MCPJ angle could be considered an acceptable range for reliable and representative measurement of the parameters included in this study.

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ETHICAL APPROVAL

As the experimental work conducted in cadavers, no ethical approved was required.

Duality of interest: The authors declare that they have no duality of interest associated with this manuscript.

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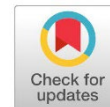
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Research Article

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The Potential Effect of Honey Varieties on Wound Healing Treatment in Dogs

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Abstract: A wound is a physical bodily injury resulting in the disruption of normal continuity of structures and wound healing is the restoration of the continuity. The objectives of the study to evaluate effects of different types of honey on wound healing in Dogs. Twenty-four healthy female dogs weighing between 8 to 12 kg were used in this study. The animals were randomly into four experimental groups with each group consisted of 6 animals over a 21-days period. After the creation of 4cm x 4cm open wound, Group I was control treated with Gentamycin ointment. Groups II, III and IV were treated with Different Types of Honey. On application, the honey was well accepted by the animals without any adverse reaction. On clinical examination, Groups II, III and IV showed bright beefy red color granulation tissue with angiogenesis when compared to Groups I. Mean percentage of epithelialization, wound contraction and total healing were significantly better in Group II (92.43%). Honey can be a better wound healing biomaterial in dogs. It can be used as a less expensive skin substitute in order to stimulate and promote wound healing in animals.

Keywords: Honey, wound healing, Sidr honey, Arbutus unedo honey, Eucalyptus honey.

التأثير المحتمل لأصناف العسل على علاج التئام الجروح في الكلاب

المستخلص: الجرح هو إصابة جسدية تؤدي إلى تعطيل الاستمرارية الطبيعية للهياكل، ويعتبر شفاء الجرح بمثابة استعادة الاستمرارية. أهداف الدراسة لتقييم تأثير أنواع مختلفة من العسل على التئام الجروح في الكلاب. استخدمت في هذه الدراسة أربع وعشرون أنثى كلب سليمة يتراوح وزنها ما بين 8 إلى 12 كجم. تم تقسيم الحيوانات بشكل عشوائي إلى أربع مجموعات تجريبية بحيث تتكون كل مجموعة من 6 حيوانات على مدى 21 يوماً. بعد تكوين جرح مفتوح بمقاس 4 سم × 4 سم، تم علاج المجموعة الأولى بمرهم الجنتاميسين. تم علاج المجموعات الثانية والثالثة والرابعة بأنواع مختلفة من العسل. عند الاستخدام، تم قبول العسل بشكل جيد من قبل الحيوانات دون أي رد فعل سلبي. في الفحص السريري، أظهرت المجموعات الثانية والثالثة والرابعة أنسجة حبيبية ذات لون أحمر ساطع مع تكوين الأوعية الدموية عند مقارنتها بالمجموعات الأولى. وكان متوسط النسبة المئوية للتشكل الظاهري وتقلص الجروح والشفاء الكلي أفضل بكثير في المجموعة الثانية (92.43%). يمكن أن يكون العسل مادة حيوية أفضل لشفاء الجروح في الكلاب. ويمكن استخدامه كبديل أقل تكلفة للجلد من أجل تحفيز وتعزيز التئام الجروح في الحيوانات.

الكلمات المفتاحية: العسل، التئام الجروح، عسل السدر، عسل الكفور، عسل الحنون.



INTRODUCTION

A wound is a physical bodily injury resulting in the disruption of normal continuity of structures and wound healing is the restoration of the continuity. The treatment of wounds has improved considerably in the past 30 years, and will continue to progress rapidly with the advancing technology and a greater understanding of chronic wounds (Ballard & Baxter, 2000; Khaled et al., 2018). The objectives of any wound management are relief of pain and distress to the animal, functional and cosmetic repair, economic and time efficient procedures and prompt decision making in the event of signs of delayed healing (Cockbill, 2002). In chronic wounds, the major focus of wound healing has been on the relationship between tissue destruction by excess inflammation and tissue synthesis stimulated by a pro-healing environment. Natural polymers have been increasingly studied for applications in health care due to their biocompatibility, biodegradability, and nontoxicity (Mali et al., 2006). Topical application of honey to wound has been recognized for centuries as effective in controlling infection and producing a clean granulating wound bed. The recorded observations show that inflammation, swelling, and pain are quickly reduced, unpleasant odors cease, sloughing of necrotic tissue occurs without the need for debridement, dressings can be removed painlessly (Dunford et al., 2000; Molan, 1999). It is one of the most enduring materials to be used in wound care, attributed to its antibacterial, anti-inflammatory, and antioxidant properties (Khaled. M. A. Hussin et al., 2021). Honey is mildly acidic and has a pH between topical acidification of wounds promotes healing (Molan & Allen, 1996; Molan & Betts, 2004). The hydrogen peroxide produced by honey is responsible for the stimulation of tissue growth. Hydrogen peroxide has been shown to stimulate fibroblast growth in cell culture at micro- and nanomolar concentrations (Schmidt et al., 1993). The medical and nutritional properties of honey depend on its chemical composition. The chemical composition of honey varies depending on the plant source, season, and production methods (Moore et al., 2001). Honey has an obvious potential for use in a variety of clinical settings, and while a few clinics and individuals are using honey therapeutically, further research is needed to determine whether the source of honey can affect wound healing. The present paper discusses the effect of different types of honey for management of an full thickness skin wound in dogs.

MATERIALS AND METHODS

Study design:

A complete randomized design was used to determine the efficacy of Different Types of Honey on wound healing in dogs. The experimental protocol was approved by the Libyan national committee for biosafety and bioethics (Reference No: LNCBB05-2022).

Animals:

Twenty-four healthy female dogs weighing between 8 to 12 kg were used in this study. The animals were randomly into four experimental groups with each group consisted of 6 animals. Group I was left untreated and acts as control group. Group II, III and IV were treated with Sidr honey, Arbutus unedo honey and Eucalyptus honey respectively. The progress of wound healing was recorded at dyes 7, 14 and Day 21 post-operation. An Elizabethan collar was applied to prevent self-mutilation of the surgical site.

Honey samples:

Three selected honeys which produced by bees from Al-Jabal Al-Akhdar Libya kept under different planting were used in this study the floral sources were Sidr honey from (Sidr) tree, Arbutus unedo honey from (Arbutus unedo) tree and Eucalyptus honey from (Eucalyptus) tree. The honeys were named according to their floral sources. all the honeys were supplied from Beekeepers Association Al-Jabal Al-Akhdar, Libya.

Surgical protocol:

Dogs were anaesthetized with an Intramuscular (IM) injection of ketamine (5 mg kg) and Xylazine (2.0 mg kg) into the caudal thigh muscle (Faraj et al., 2022). When fully anaesthetized, the animals were positioned on their dorsal area which was prepared aseptically for the creation of an open wound (4x4 cm). The skin was disinfected with hibiscrub, containing 0.6% chlorohexidin then with 70% alcohol solution and with 2% iodine solution (Druecke et al., 2004). Using a sterile millimetre ruler and cotton tipped applicator dipped in sterile methylene blue, a 4 cm² was drawn on the skin. A full thickness skin defect in which all tissue down to and including the panniculus muscle was excised using no. 15 scalpel blade. The wound was covered with honey and kept on the wound and protected with a bandage. The limb was immobilized using a PVC splint and bandage.

Assessment of the wound:

The progress of open wound healing was recorded at 0, 7, 14 and 21 days post-wounding. All the wounds were digitally photographed in the presence of a standard reference ntler.

The wound and its circumference were measured using the ON 3D Measure application. Where this was done by taking pictures of the wounds, and this application calculates the length, depth and width of the wound accurately.

Percentage of wound contraction was calculated by:

Step 1: Total wound on dayn = Total wound area dayn / original wound area day 0 x1 00.

Step 2: Wound on dayn (%)= 100) =total wound on dayn as % of original.

Histopathological analysis:

The skin samples were taken for histopathological examination at day 7, 14 and 21 post-operations. The skin samples were fixed in 10% formalin solution and embedded in paraffin. Tissue sections of 4-5 mm thickness were cut, stained with Haematoxylin and Eosin (H&E) and examined under light microscope. Digital photomicrographs were captured at representative locations using a digital camera attached to a Nikon Eclipse FX-35DX microscope.

Statistical analysis:

Data are expressed as mean±Standard Deviation (SD). The statistical analysis of data was performed using 2-way ANOVA using the SPSS® Statistical package (SPSS, Version 20.0, Chicago, Illinois, USA). The effects with p<0.05 were considered statistically significant.

RESULTS

The percentage of wound contraction was better in group IV up to day 14 (58.78%), however it was best in group II on days 14 and 21. The difference between groups II, III and IV compared to group I was evident on day 7. The percentage of wound contraction improved from 57.84% (day 14) to almost 92.43% on day 21 in group II but group IV showed an improvement from 17.56% (day 7) to almost 82.67% on day 21 and group III showed an improvement from 16.09% (day 7) to almost 78.12% on day 21. Nevertheless, group II demonstrated better than average total wound healing throughout the trial (Table 1).

Table: (1). Percentage of wound contraction mean.

Days	Control Group I	Sidr Group II	Arbutus unedo Group III	Eucalyptus Group IV
0	0	0	0	0
7	15.90%	16.20.65%	16.09%	17.56%
14	40.90%	57.84%	42.65%	58.78%
21	68.93%	92.43%	78.12%	82.67%

Values with different superscripts within a row differed significantly at p<0.05

No unabsorbed remnants were noticed during the next application. In groups I, III and IV animals, the wound colour was red up to day 14 post-operation and pink in colour from day 21. Groups II showed bright beefy red colour up to day 14 and it were Pink from day 21. Malodour was observed up to day 14 post-operation in group I and II animals. In group III and IV mild malodour were observed up to day 7. Serous exudate was noticed up to day 14 in group I. Mild serous exudate was noticed up to day 7 post-operation in groups III and IV animals. No exudate was seen in group II animals throughout the study (Figure. 1, 2 and 3).



Figure: (1). Open wound on day 7 post-wounding: post-wounding: A=Control group I, B= Sider Group II, C= Arbutus unedo group III, D= Eucalyptus group IV.



Figure: (2). Open wound on day 14 post-wounding: post-wounding: A=Control group I, B= Sider Group II, C= Arbutus unedo group III, D= Eucalyptus group IV.



Figure: (3). Open wound on day 21 post-wounding: A=Control group I, B= Sider Group II, C= Arbutus unedo group III, D= Eucalyptus group IV.

Histopathological Study

After 21 days of injury, epidermal regeneration was observed in all experimental wounds. Histopathologic comparisons showed that on day 21, sidr hony treated wounds resulted in better re-epithelialization as compared to the control, Arbutus unedo hony and Eucalyptus hony treated dogs. In addition, the inflammatory cells were absent in all treated wounds. In the sidr hony, though new epithelium was noted to regenerate, inflammatory cells particularly neutrophils and macrophages were still present on the upper dermis. Less scab formation was seen in the wounds treated with Arbutus unedo hony, Eucalyptus hony and untreated control wounds (Fig. 4,5,6).

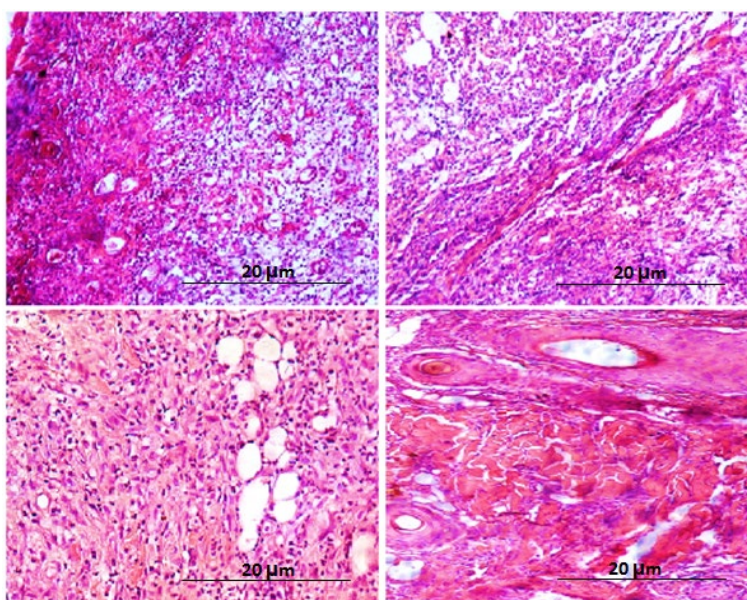


Figure: (4). Histopathology of the granulation tissue from the open wound day 7 post-wounding: A= group I, B= group II, C= group III, D= group IV. (H and E stain 40x); E = Endothelial cell; G = Granulation tissue; V = Blood Vessel.

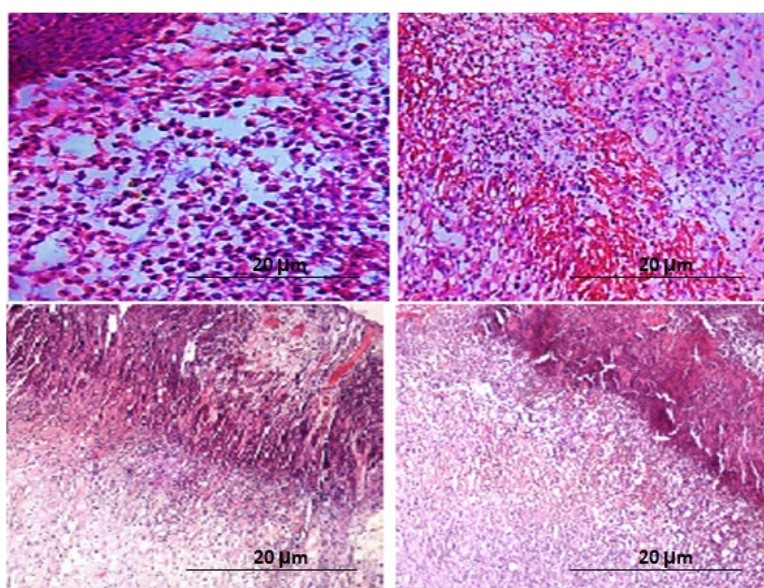


Figure: (5). Histopathology of the granulation tissue from the open wound day 14 post-wounding: A= group I, B= group II, C= group III, D= group IV. (H and E stain 40x); E = Endothelial cell; G = Granulation tissue; V = Blood Vessel.

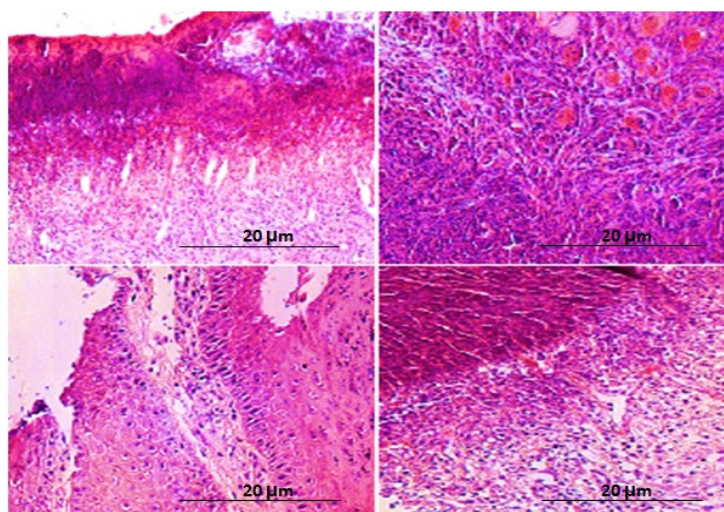


Figure: (6). Histopathology of the granulation tissue from the open wound day 21 post-wounding: A= group I, B= group II, C= group III, D= group IV. (H and E stain 40x); E = Endothelial cell; G = Granulation tissue; V = Blood Vessel.

DISCUSSION

In Groups II, III and IV, the application of honey was well tolerated by the animals. The honey is easy to apply on the wound without any adverse reaction and was well accepted by all the animals. The application of Sidr honey did not show any adhesion of the gauze during wound dressing. The colour of the wound bed in Group II was red while Groups I, III and IV showed a bright beefy red colour, which indicates healthy granulation tissue with neovascularisation, (James & Bayat, 2003) and resistance to infection until the epithelial barrier is re-established (Hosgood, 2003; Khaled et al., 2022; Pope, 1993).

The bright red colour observed is due to the micro vascular network throughout the granulation tissue (Tonnesen et al., 2000). The basic fibroblast growth factor set the stage for angiogenesis during the first three days of wound repair (Schäffer et al., 2004) and plays an important role in granulation tissue formation and the wound healing process (Takehara, 2000). Granulation in all the cases was flat without any exuberant nature; granulation tissue with a smooth surface facilitates migration of epithelial cells (Pope, 1993). On Days 21, the granulation tissue was observed to be pink in colour in all Groups, which indicates the final stage of wound healing. (James & Bayat, 2003). Mal-odour was observed up to Day 12 in Groups I; however, in Groups III and IV mild mal-odour was observed up to Day 7 which may be due to infection (James & Bayat, 2003). The presence of bacterial infection was the common cause for the mal-odour observed, because all the wounds were infected. Serous discharge was noticed up to Day 14 in Group I and mild serous discharge was noticed up to Day 7 in Groups III and IV; subsequently, the discharge was reduced because healthy vascular granulation tissue is resistant to infection (Hosgood, 2003; Pope, 1993).

Wound epithelialisation of Group II was consistently better than Group I, and also better than Groups III and IV because the reepithelialisation process in a full-thickness wound is accelerated by the presence of collagen and its proliferation is essential for optimal wound healing (Rangaraj et al., 2011). The percentage of wound contraction on post wound Days 7 of all Groups showed no significant difference, this may be because of an inherent property of fibroblasts that appears early in the process of wound contraction, which, after some time, do not contract as forcefully as those that appear later (Bohling et al., 2004b; Khaled. M. A et al., 2014). reported that (Schäffer et al., 2004) there is increased fibroblast activity of the body until post-wound Day 14. On Days 14 and 21,

Group II was significantly better than Groups I, III and IV since basic fibroblast growth factor effectively accelerated wound fibroblast proliferation (Kawai et al., 2000) and has a characteristic myofibroblastic appearance, which plays a critical role in closure and healing (Cheng et al., 1999).

The mean percentage of wound contraction of Group II on Day 21 was significantly better than other groups; in open wounds, contraction becomes an important feature and epithelialisation assumes a more predominant role. However, the two processes are independent of each other (Khaled et al., 2016; Probst, 2003). All the groups showed maximum rates of contraction in the period between Days 7 and 14 post-wound; similar findings have been previously reported (Aljady et al., 2000; Baie & Sheikh, 2000; Bohling et al., 2004b; Jothi et al., 2006). The percentage of total wound healing of Group II was significantly better than Group I and consistently better than Group III and IV because of more rapid epithelialisation; there is a corresponding reduction in area of exposed granulation tissue in the wound (Bohling et al., 2004b). On Day 20, among Groups II, III and IV there was no significant difference but healing was significantly better than in Group I. Basic FGF is well known for promoting the proliferation of almost all cells associated with wound healing (Michiyo et al., 2005). All the groups showed maximum mean percentage of total wound healing from Days 7 to 14; this is in concurrence with the results of (Bohling et al., 2004a) but differs from the findings of (Swaim et al., 1993).

Sidr honey is a biocompatible protein that does not interfere with the body's normal immunologic response and can be used in non-healing chronic wounds, which require a trigger to stimulate the normal healing process.

CONCLUSION

Honey can be a better wound healing biomaterial in dogs. It can be used as a less expensive skin substitute in order to stimulate and promote wound healing in animals.

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ETHICS

The protocol for the research project and the animals experimental for research was approved by the Libyan National committee for Biosafety & Bioethics of the faculty of Veterinary Medicine, Omar Al-Mukhtar University (LNCBB-05-2022).

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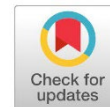
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Research Article

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Libyan local pigeon: Preliminary description of meat characteristics

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Abstract: Pigeon is one of the potential alternative poultry species for meat production. Meat characteristics of Libyan local pigeon have not been previously described. The current study aimed to describe the characteristics and chemical composition of Libyan local squab carcasses. The study was conducted on six chicks of Libyan local squab (28 – 40 days old). The birds were deprived of food and water for 12h and weighed (live body weight). The birds were slaughtered and scalded in hot water (85°C) immediately after bleeding and carcasses were eviscerated and weighed. The mean live body weight and eviscerated carcass weight of birds were 283.38 and 207.81g, respectively. The dressing percentage of squabs was 73.36%; the breast and leg (thigh + drumstick) represent the highest cuts: 34.91% and 5.82% of carcass weight, respectively. Meat to bone ratio in breast, thigh, wing and back cuts was 10.55, 5.49, 3.12 and 3.16, respectively. Squab meat content of moisture, crude protein, crude fat and ash were 67.01, 21.72, 8.78 and 1.19 %, respectively. Based on the results obtained from the present study, Libyan local pigeon meat can be considered as one of the potential alternative poultry meat in the local meat market.

Keywords: Component; Formatting; Style; Styling; Insert (3-6 words)

الحمام المحلي الليبي: وصف مبدئي لخصائص اللحم

المستخلص: يعد الحمام أحد أنواع الدواجن البديلة الممكنة لإنتاج اللحوم. خصائص الذبيحة في فراخ الحمام المحلي الليبي لم يتم توصيفها من قبل. تهدف هذه الدراسة إلى وصف مبدئي لخصائص ذبيحة فراخ الحمام المحلي وتركيبها الكيميائي. أجريت الدراسة على ستة فراخ من سلالة الحمام المحلية الليبية تتراوح أعمارها بين (28-40 يوماً). منعت الطيور من الطعام والشرب لمدة 12 ساعة ووزنت (الوزن الحي)، ثم ذبحت ونزع ريشها باستخدام ماء ساخن (85 درجة مئوية) وأزيلت أحشاءها الداخلية وسجل وزن الذبيحة. بلغ متوسط الوزن الحي ووزن الذبيحة المنزوعة الأحشاء 283.38 و 207.81 جرام، على التوالي. كانت نسبة التصافي 73.36%. يمثل الصدر والرجل (الفخذ + عصا الطبال) أعلى القطعيات: 34.91% و 5.82% من وزن الذبيحة، على التوالي. كانت نسبة اللحم إلى العظم في قطعيات الصدر والفخذ والجناح والظهر 10.55 و 5.49 و 3.12 و 3.16 على التوالي. كان محتوى لحم الفراخ من الرطوبة والبروتين الخام والدهن الخام والرماد 67.01 و 21.72 و 8.78 و 1.19%، على التوالي. بناءً على النتائج المتحصل عليها من الدراسة الحالية، يمكن أن يشكل لحم الحمام أحد أنواع لحوم الدواجن البديلة في سوق لحوم الدواجن المحلي.

الكلمات المفتاحية: حمام، ذبيحة، لحم



INTRODUCTION

Meat consumption in developing countries has been continuously increased (Delgado, 2003). Intake of protein derived from animal origin represents only 27% of protein consumption in Libya (FAO, 2005) versus 62% in the United States of America (Pasiakos, 2015). This leads to a growing interest in meat from alternative animal species like ostriches, ducks, rabbits and pigeons to fulfil this gap. World production of poultry meat has been rising because of relatively low price compared to other meat types (Scanen, 2007). Squab meat is excellent and is considered, in comparison to poultry meat, what veal is to beef (Parkhurst & Mountney 1988). The main primal cuts of the poultry, particularly pigeon: breast and leg muscles have healthy fatty acid profile, with a high content of polyunsaturated fatty acids (Pomianowski et al., 2009). The purpose of pigeon breeding was according to three categories: sports pigeons, ornamental pigeons, and utility (meat type) pigeons (Fekete et al., 1999; Al-Agouri et al., 2021). In Libya, pigeons are mainly raised in rural areas with an increased number of urban breeders of sports and ornamental pigeon exotic breeds. The limited availability of pigeons, the absence of the tradition of consuming pigeon meat, in addition to the relatively high price of pigeon squabs compared to broiler chickens, has made pigeon meat less popular in Libya in similar to the situation in other countries like Poland (Kokoszyński et al., 2013). China is the largest producer of meat pigeons with 80% of global production and annual production of about 680 million pigeon squabs (Jiang et al., 2019). Pigeon meat is obtained by slaughtering young squabs at 28–30 days of age (Dal Bosco et al., 2005). Pigeon meat contains 66.52-76.23% of water, 21.73-23.61% of protein, 1.54-7.07% of fat and 1.05-1.48% of ash (Dal Bosco et al., 2005; Pomianowski et al., 2009; Abdel-Azeem et al., 2016). Breed (Pomianowski et al., 2009), diet (Liu et al., 2006) and age (Bu et al., 2018) are principal factors of variation in meat chemical composition.

Information about the productive and reproductive performance of Libyan local pigeon was previously described (Akraim & Jadallah 2021; Akraim et al., 2022). However, information about their carcass characteristics is not available. Therefore, the objective of the current study was to provide preliminary information on the proximate components and carcass traits of Libyan local squab meat.

MATERIALS AND METHODS

Birds, slaughtering and preparation of pigeon squab carcass

A total number of six birds of Libyan local pigeon squabs (aged 28-40 days), were obtained from the Animal Production Department's experimental house, a College of Agriculture at Omar Al-Mukhtar University. Their parents received a pelleted ration composed of corn, wheat, and soybean meal (Table 1). Housing and management of birds were previously described (Akraim et al., 2022).

Table:(1). Ingredients and chemical composition of total mixed ration

Ingredients %		Chemical composition %	
Corn	66	DM	88
Wheat	10.50	Crude protein	15.5
Soybean meal	18.60	Crude fiber	2.71
Dicalcium phosphate	1.20	Ether extract	3.88
Limestone	2.40	Ash	1.00
Salt	0.30	Soluble carbohydrate	76.1
Vit-min complex	1.00		

After collection, the birds were fasted for 12 hours, weighted (live weight), and slaughtered according to local practice, where halal necks were cut. Then they were immediately hoisted to permit

thorough bleeding. Scalding was done in hot water (85C°) immediately after bleeding. The carcasses were defeathered, eviscerated and weighed (Hot carcass weight), then cut up into primal cuts (breast, leg muscles: all muscles from both thighs and drumstick muscles, back and both wings) and the weight of each cut was recorded. Dressing percentage was determined as hot carcass weight/live weight x 100.

Meat-to-Bone Ratio

This was carried out on each primal cut. Each of the cuts was boiled for 20 minutes, and the flesh, including the skin, was separated from the bones and weighed. Proximate analysis of moisture content, crude fat, crude protein and total ash was carried out on selected raw meat primal cuts (leg and breast) according to the method described by (AOAC, 2000).

The data was subjected to descriptive statistics in Microsoft Excel® 2016 software, and presented as means $\pm$ standard error.

RESULTS AND DISCUSSION

Meat chemical composition

A proximate analysis of squab meat is presented in Table 2. The moisture content of local squab meat was 67.01%. The closest results were reported by Pomianowski et al. (2009), who found 66.52%, 69.94%, and 70.59% of moisture content in three different pigeon breeds.

Table:(2). Proximate composition of squab meat (%)

Variable	Means $\pm$ SD
Moisture	67.01 $\pm$ 6.74
Crude protein	21.72 $\pm$ 0.62
Crude fat	8.78 $\pm$ 1.27
Ash	1.19 $\pm$ 0.17

The crude protein and fat contents of squab meat in this study were 21.72% and 8.78%, respectively. Protein and fat in muscle tissue are important meat quality parameters and contribute substantially to the nutritional characteristics of meat. Poławska et al. (2013) reported a comparable protein content in squab meat of 21.70%, but a lower fat content of 4.3%. However, Pomianowski et al. (2009) showed that the protein content of squab meat varied from 20.56 to 23.61%, and the fat content from 4.32 to 7.85% in three different pigeon breeds. The variation in nutrient content may be due to different diets consumed by the birds (Abdulla et al., 2019). On the other side, Dal Bosco et al. (2005) revealed that the percentages of moisture, protein, fat and ash in white king pigeons in Italy were 76.23%, 21.18%, 1.54% and 1.05%, respectively. In general, pigeon meats are fatty and contain all essential amino acids in the amounts and proportions required by the human body (Elsayed et al. 1980). Nevertheless, additional researches are needed to create more awareness regarding the fatty acid profile in local pigeon meat, particularly poly unsaturated fatty acids and their relation with lipid oxidation (Abdulla et al., 2019). As mentioned earlier, breed, diet, age and cut type could be sources of variation in meat chemical composition (Liu et al. 2006, Pomianowski et al. 2009, Bu et al. 2018).

Intramuscular fat influences meat taste, consistency and acceptability. Between 2.2% and 3.4% of intramuscular fat is the minimum recommended to ensure a good taste of meat (Font-i-Furnols et al. 2012). Ash content indicates the number of minerals found in food. The ash content in food determines the extent to which dietary minerals can be available in food (Ogunmola et al 2013). The average ash content of squab meat in our study was 1.78%. This result is higher than the results re-

ported by Pomianowski et al. (2009) on Wrocławski, King and Europigeon squab meat breeds: 1.11, 1.48, 1.42%, respectively; or the result reported by Dal Bosco (2005), who found 1.05% ash in white king squab meat. Gašperlin et al. (2006) reported that ash content exhibited significant differences due to genotype, age and sex.

Carcass parameters

In the present study, measurements were made for live body weight, carcass weight, dressing percentage and percentage of carcass cuts.

These cuts were at the breast, the leg, the back, and the neck. The results are shown in Table 3. It was noted from the results presented in Table 2. that the average live body weight of weaned squabs was (283.38 g).

Table:(3). Carcass characteristics of Libyan local pigeon squab meat

Items	Value
Live body weight	283.38 ± 13.75 g
carcass weight	207.81 ± 18.78 g
Dressing percentage	73.30 ± 4.45 %
Breast	34.91 ± 2.10 %
Wing*	9.80 ± 0.53 %
Leg*	5.82 ± 0.12 %
Back	21.77 ± 0.23 %
Neck	6.46 ± 0.54 %

* One leg, one wing

This was in agreement with the range of weights reported previously for this breed by (Akraim and Jadallah 2021; Akraim et al. 2022). The average dressing percentage of squab in this study was 73.30%. This percentage was similar to the dressing percentage reported in domestic pigeons in the Indian province of Assam (71.48%), but higher than that of domestic pigeons in the Sokoto region of Nigeria (66.02%), Giribaz breed (53.88%) or Egyptian domestic pigeon (52.15%) (Khargharia. et al. 2002, Omojola et al. 2012, Hasan et al. 2016, Abdel-Azeem et al. 2016). Dressing percentage is affected by genetic factors such as breed type and sex, or non-genetic factors such as feed and age (Coyne et al. 2019). This is evidenced by the increase in dressing value in Egyptian pigeons from 55.20% to 70.10% with increasing protein and energy in the feed (Omar et al. 2017). The higher the dressing out percent, the better in terms of economic returns (Omojola, 2007).

The percentage of squab carcass parts can be seen in Table 4. These carcass parts have consisted of the breast, leg, back, and wing. The breast represented the highest cut of squab carcass 34.91% followed by back cut 21.77%, wing 9.80%, neck 6.46% and leg 5.82%. Pomianowski et al. (2009) reported that breast and leg cuts represent 28.70-30.60% and 5.50-7.10%, respectively.

Meat to Bone ratio

From Table 3. It can be noted that the breast has the highest percentage of meat 10.55, followed by leg 5.49, neck 4.81, while the lower observed values were for the back and wing: 3.16, 3.12, respectively.

Table:(4). Meat-to-Bone ratio of primal cuts of squabs.

Cuts	Means ± SD
Breast	10.55 ± 2.75
leg	5.49 ± 0.66
Wing	3.12 ± 0.26
Back	3.16 ± 0.56
Ash	1.19 ± 0.17

Apata et al. (2015) found lower meat to bone ratio in breast cut (7.96). Moderate excess of dietary protein above requirements increases carcass and breast meat yields and decreases fattening in broilers (Bartov and Plavnik 1998). Ganabadi et al. (2009) found that the breast meat to bone ratio was higher in broilers compared to jungle fowl and they attribute this difference to habitat and feeding pattern.

CONCLUSION

It can be concluded from the present study that the meat of the Libyan local domestic pigeons may also be utilized to fulfill the protein requirements, and these species should be considered in the existing poultry industry.

Duality of interest: The authors declare that they have no duality of interest associated with this manuscript.

Author contributions :Contribution is equal between authors.

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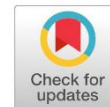
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Research Article

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Ecological assessment and diversity of woody plants in plantations of frankincense trees (*Boswellia papyrifera* (Del.) Hochst.) in AlGerri Forest, Blue Nile State, Sudan

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Abstract: This study was aimed to evaluate the diversity of shrub and tree species growing under *Boswellia papyrifera* tree plantation of AlGerri forest reserve in Blue Nile State. 18 systematic circular sample plots of 0.1 ha. (Radius = 17.84) with intervals of 100 m between each plot were used to collect data. A total of 13 woody species belonging to 7 families were determined in two *Boswellia papyrifera* plantation communities. *Boswellia papyrifera* dominated the woody species in all vegetation communities, followed by *Combretum hartmannianum* and *Vachellia seyal*. The Shannon diversity indexes (H) of community number one and community number two were 0.328 and 0.429 respectively. Pielous Evenness index (E) values in both communities were 0.344 and 0.429 respectively. The density of both communities was 609.1 and 309.08 plant/ha. respectively. The distribution of woody species showed that 61.54% of species were aggregated and 38.46% of species were randomly distributed. Cluster analysis based on the Bray-Curtis single linkage was used to assess the similarity between woody species composition across the 18 sampled plots.

Keywords: *Boswellia papyrifera*; plantation; diversity; distribution; similarity.

Boswellia papyrifera (Del.) Hochst. التقييم البيئي وتنوع النباتات الخشبية في مزارع أشجار اللبان (Boswellia papyrifera (Del.) Hochst.) في غابة الجري، ولاية النيل الأزرق، السودان

المستخلص: هدفت هذه الدراسة إلى تقييم تنوع أنواع الشجيرات والأشجار داخل مزارع اشجار اللبان (*Boswellia papyrifera* (Del.) Hochst.) في منطقة القرى بولاية النيل الأزرق. 18 نماذج دائرية منتظمة حددت لاختذ وتسجيل البيانات تبلغ مساحة الواحد منها 0.1 هكتار. (نصف القطر = 17.84) مع مسافات تباعد تبلغ 100 متر بين كل نموذج والآخر، تم استخدامها لجمع البيانات. تم تحديد ما مجموعه 13 نوعاً خشبياً تنتمي إلى 7 عائلات في مجموعتين من مزارع اشجار اللبان. ساد نوع اشجار اللبان (*Boswellia papyrifera*) على الأنواع الخشبية في جميع مجتمعات الغطاء النباتي، وتليها أنواع الهبيل (*Combretum hartmannianum*) والطلح (*Acacia seyal*). كان مؤشرا التنوع في شانون (H) للمجتمع (1) والمجتمع (2) 0.328 و 0.429 على التوالي. كانت قيم مؤشر Pielous Evenness (E) في المجتمع (1) والمجتمع (2) 0.344 و 0.429 على التوالي. كثافة المجتمع (1) والمجتمع (2) 609.1 و 309.08 نبات / هكتار. على التوالي. أظهر توزيع الأنواع الخشبية أن 61.54% من الأنواع تتواجد في تجمعات في توزيعها و 38.46% من الأنواع موزعة عشوائياً. تم استخدام التحليل العنقودي المستند إلى الرابط الفردي Bray-Curtis لتقييم التشابه بين تكوين الأنواع الخشبية عبر 18 نموذج عينة.

الكلمات المفتاحية: التقييم البيئي، النباتات الخشبية، أشجار اللبان، منطقة القرى، ولاية النيل الأزرق، السودان.



INTRODUCTION

Sudan is a vast country that exhibits wide variation in climate, topography, and soils. It has a total area of approximately 1.882 million km². It lies between latitude 4° -22° N. and longitude 22°-26° E. and covers a wide range of habitat varying from desert in the north to high rainfall wood land savanna in the south. *Boswellia papyrifera* in Sudan is a common savanna tree that occurs on rocks or hill, slopes in low rainfall wood land savanna (Harrison & Jackson, 1958). Naturally *Boswellia papyrifera* covers large areas in different parts of Sudan south latitude 14° N, includes Blue Nile (around Jebel Gerri and Fung) and in the eastern Sudan extending from Gala-al-Nahal to Kurmuk (Khan, 1972). In South Kordofan it occurs in the Nuba mountains (El Amin, 1990). In North Kordofan on higher slopes of Jebel ElDair (Ismail & Mahmoud, 2010).

Boswellia papyrifera tree faces problem of natural regeneration, which was observed by Khan, who reported zero regeneration in Blue Nile State (Khan, 1972). This obviously means that the species is decreasing due to absence or difficulties of natural regeneration. This situation coupled with the recent tree use for fodder and repeated tapping for resin of this tree. In spite of this phenomenon of absence of natural regeneration of *Boswellia papyrifera* tree but still there is some regeneration of other woody species in both stands. This study aimed to evaluate the diversity of shrub and tree species growing under the *Boswellia papyrifera* tree plantation of AlGerri forest in Blue Nile State.

MATERIALS AND METHODS

Study area

The study was carried out in AlGerri, Blue Nile State, 30 km southeast of Eldamazin Town (Figure 1). It is characterized by heavy rainfall starting from April to November ranging from 300-800 mm/annum with peak months being July and September. The mean maximum temperature ranging between 32 °C to 40 °C and mean minimum temperature between 17 °C to 26 °C, with 20% to 80% relative humidity (Osman & Idris, 2012). The soil is cracking clay soil away from the hill, turning to gravelly light clay soil with good drainage.

Data collection

The vegetation data were collected from 18 systematic circular sample plots of 0.1 ha. (Radius = 17.84) with intervals 100 m between each plots, along 2 line transects across the plantations using GPS (Garmin version 12). Plant species in each plot were counted and recorded at individual level, and plant specimens were also collected, numbered, pressed and taken to Soba Forests Herbarium, Forestry Research Centre, for identification, confirmation and deposition following standard classification systems (Bridson & Forman, 1992).

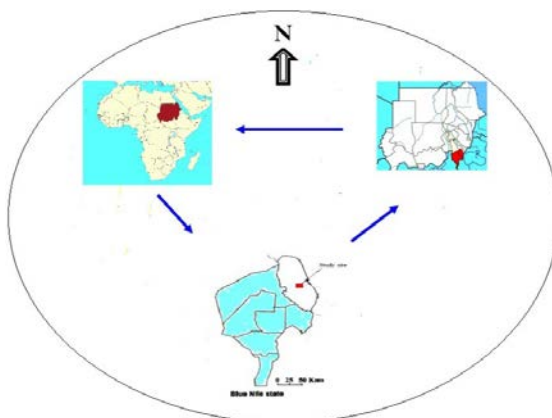


Figure: (1). Map of study area.

Data analysis

Phytosociological parameters

Relative density, relative abundance and relative frequency were estimated following Misra method (Misra, 1968), while the Importance Value Index (IVI) was estimated by adding the values of RD, RA and RF using the Shukla and Chandel method (Shukla & Chandel, 1980).

Diversity indices

Species richness was determined as the total number of species present in the studied site. The Shannon diversity index was applied to estimate woody plant species diversity along the study area (Shannon & Weaver, 1963). This index was calculated by the equation $H_s = -\sum p_i \ln p_i$. Where, p_i is the proportion of individuals found in the i th species and 'ln' denotes the natural logarithm. Pielou index was used for estimation of species evenness (E) after Pielou (Pielou, 1966). This index was calculated by the equation $E = H'/\ln S$. Where: H' is the Shannon-Wiener diversity measure, S is Number of species.

Species distribution test and Comparisons of woody plant species composition between different plots were estimated using single linkage cluster analysis based on Bray-Curtis similarity (McAleece, 1998), Biodiversity Pro. version 2.

RESULTS

Floristic Composition and Diversity of Species

A total of 13 woody species belonging to 7 families were determined in both *Boswellia papyrifera* plantation communities (close to hill community number one and close to clay community number two (Table 1). 9 species were recorded in community [1] and 10 species in community [2]. The family with highest number of species in community [1] was Combretaceae with 3 species, followed by Fabaceae with 2 species. In stand (2) the highest representation was of Combretaceae and Fabaceae with 3 species for each. The Shannon diversity indexes (H) of both communities were 0.76 and 0.99 respectively. The results also revealed that the Pielous evenness index (E) values in community [1] community [2] were 0.344 and 0.429 respectively. While the density of community [1] and community [2] were 609.1 and 309.08 plant/ha. respectively (Figure 2).

Table: (1). Characteristic feature of the studied samples.

Sample plot	Soil Type	Community
1	Pure Rocky and stony	1
2	Pure Rocky and stony	1
3	Pure Rocky and stony	1
4	Pure Rocky and stony	1
5	Pure Rocky and stony	1
6	Pure Rocky and stony	1
7	Pure Rocky and stony	1
8	Pure Rocky and stony	1
9	Rocky and stony mixed with cracking clay	2
10	Rocky and stony mixed with cracking clay	2
11	Rocky and stony mixed with cracking clay	2
12	Rocky and stony mixed with cracking clay	2
13	Rocky and stony mixed with cracking clay	2
14	Pure Rocky and stony	1
15	Pure Rocky and stony	1
16	Rocky and stony mixed with cracking clay	2
17	Pure Rocky and stony	1
18	Rocky and stony mixed with cracking clay	2

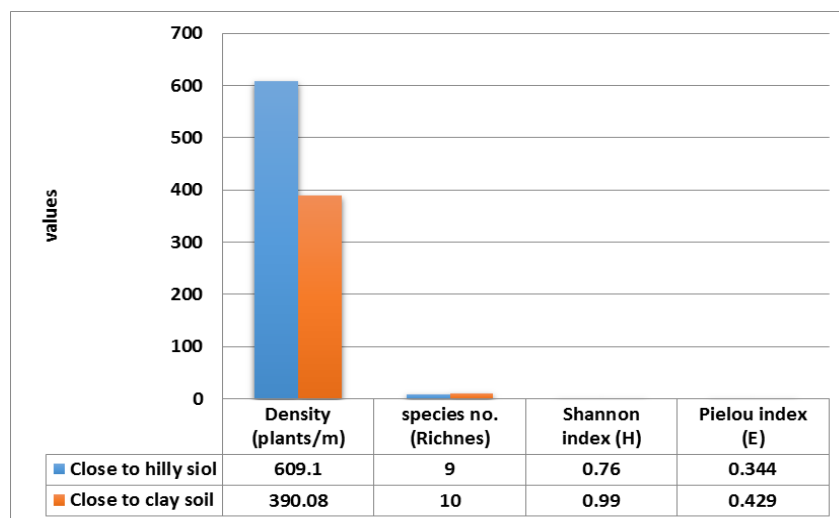


Figure: (2). Species richness, diversity indices and density of the two communities

Phytosociological parameter

Relative density ranges between 76.72 and 0.15 in community [1] and between 72.88 and 0.38. The highest values of relative density were recorded by *Boswellia papyrifera* (76.72 and 72.88%) in both communities respectively and followed by *Combretum hartmannianum* (17.76%) in community [1] and by *Vachellia seyal* (19.92%) in stand [2]. While the lowest value in stand [1] was (0.15%) recorded for *Combretum collenum* and in stand [2] was (0.38%) recorded for *Lannea fruticosa*. Also *Boswellia papyrifera* recorded highest relative abundance and relative frequency in both stands, followed by *Combretum hartmannianum* in community [1] and *Vachellia seyal* in community [2].

Dominance of species was determined based on the calculated IVI values. It was found that in community [1] *Boswellia papyrifera* was the dominant species with highest IVI (172.45) followed by species like *Combretum hartmannianum*. (61.6), *Lannea fruticosa* (27.14), *Pterocarpus lucens* (8.83) etc. *Boswellia papyrifera* also dominated stand [2] with highest value of IVI (151.56) followed by *Vachellia seyal* (45.74), *Combretum hartmannianum* (30.74), *Anogeissus leiocarpa* (17.17), *Zizphus spina-christi* (10.88) etc. (Table 2).

Species distribution

Distribution of woody species was assessed and results showed that 61.54% of species were aggregated, included *Boswellia papyrifera*, *Balanites aegyptiaca*, *Calotropis procera*, *Vachellia seyal*, *Combretum aculeatum*, *Combretum hartmannianum*, *Lannea fruticosa* and *Pterocarpus lucens*. While 38.46% of species were randomly distributed, these includes *Senegalia senegal*, *Anogeissus leiocarpa*, *Combretum collenum*, *Lonchocarpus laxiflorus* and *Zizphus spina-christi*. (Table 2).

Similarity

Cluster analysis based on the Bray-Curtis single linkage similarity value, revealed the similarity between woody species composition across the 13 sampled plots. Sample plot 7 and sample plot 14 shows highest similarity with percentage 93.1% (Figure 2), this may be due to the similar habitat of both samples, especially the two samples located in the same type of soil (Table 1), followed by 91.7% which indicated the similarity between sample 10 and sample 15. While sample plot 1 and sample plot 8 shows lowest similarity with percentage 46.8%.

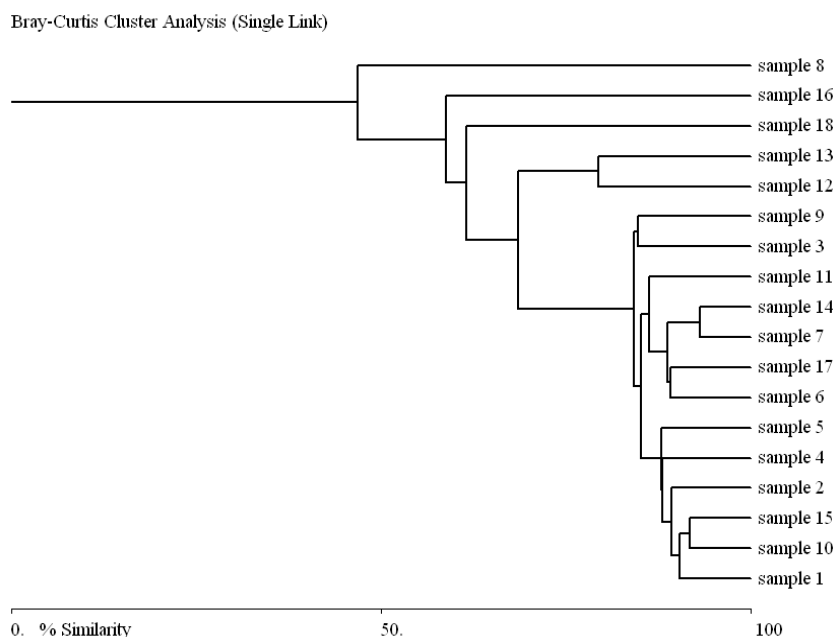


Figure: (3). Similarity between different sampled plots of study area, using Bray-Curtis (CN, quantitative version of Sorensen index) index.

Table: (2). Phytosociological parameters and Distribution pattern of woody plant species in both communities.

Family	Plant species	Relative density		Relative abundance		Relative frequency		IVI		Distribution pattern
		hilly	clay	hilly	clay	hilly	clay	hilly	Clay	
Anacardiaceae	<i>Lannea fruticosa</i> (Hochst. ex A. Rich.) Engl.	2.54	0.38	3.01	1.92	21.59	3.45	27.14	5.75	Aggregated
Apocynaceae	<i>Calotropis procera</i> (Aiton) Dryand.	1.19	0	2.83	0	0.15	0	4.17	0	Aggregated
Burseraceae	<i>Boswellia papyrifera</i> (Del.) Hochst.	76.72	72.9	66.1	54.5	29.7	24.2	172.5	151.6	Aggregated
Combretaceae	<i>Anogeissus leiocarpus</i> (DC.) Guill. & Perr	0.3	1.46	1.41	1.92	5.4	13.8	7.11	17.17	Random
	<i>Combretum aculeatum</i> Vent.	0	0.73	0	3.84	0	3.45	0	8.02	Aggregated
	<i>Combretum collinum</i> subsp. <i>Binderianum</i> (Kotschy) Okafa.	0.15	0	1.41	0	2.702	0	4.262	0	Random
	<i>Combretum hartmannianum</i> Schwein f. Beitr.	17.76	6.59	16.8	6.91	27.02	17.2	61.6	30.74	Aggregated
Fabaceae	<i>Senegalia senegal</i> (L.) Britton	0	0.73	0	1.92	0	6.9	0	9.6	Random
	<i>Vachellia seyal</i> (Delile) P.J.H. Hurter.	0	13.9	0	14.6	0	17.2	0	45.7	Aggregated
	<i>Lonchocarpus laxiflorus</i> Guill. & Perr.	0.3	0	1.41	0	5.4	0	7.11	0	Random
	<i>Pterocarpus lucens</i> Guill. & Perr.	0.6	1.1	2.83	5.75	5.4	3.45	8.83	10.3	Aggregated
Rhamnaceae	<i>Ziziphus spina-christi</i> (L.) Desf.	0	1.1	0	2.88	0	6.9	0	10.88	Random
Zygophyllaceae	<i>Balanites aegyptiaca</i> (L.) Delile	0.45	1.1	4.24	5.75	2.702	3.45	7.392	10.3	Aggregated

DISCUSSION

From the results maintained above both communities, the values of Shannon diversity and Pielous evenness indices, were relatively low when compared with that of Jebel ElGerri which recorded the values (1.733245) for Shannon index and (0.5201) for Pielous index, this may have attributed to the highly dominance of one species (*Boswellia papyrifera*), which agreed with the fact the low evenness value indicates the dominance of the environment by few species (Van Breugel et al., 2007).

The results showed the IVI value of *Boswellia papyrifera* in community [1] is higher than that of community [2]. This observation due to that community [1] is characterized by pure rocks and hill slopes, which is the favorite habitat for this species as mentioned previously (El Amin, 1990; Harrison & Jackson, 1958; Wickens, 1976). However, in stand [2] the presence of clay may reduce favorite properties of the soil beside the extensive tapping for frankincense yield in both stands, which may cause the death of trees, which result in open spaces, that encourage the appearance of other species to compete the original plantations.

Appearance of *Combretum hartmannianum* in stand [1] with highly density and secondly in dominance beside *Boswellia papyrifera*, this attributed to that these species common savanna trees that occurs on rocky steep slopes of the hills in high rainfall savanna (Harrison & Jackson, 1958). On the other hand, the high values of relative density, abundance, frequency and IVI of *Acacia seyal* in stand [2] this attributed to suitability of site properties especially cracking clay soil, which limit the natural distribution of this species.

Boswellia papyrifera was distributed aggregately, because it was cultivated in close constant spacing (2*2 m). *Balanites aegyptiaca* and *Acacia seyal* these two species characterized by their association especially in cracking clay soil of low rain fall woodland savanna under clay as described by Harrison and Jackson (Harrison & Jackson, 1958). Meanwhile, it found in stand [2] only in patches, where its soil consists of large amount of clay, gravel and stony compounds, this is due to its location away from the hill and close to clay soil. While *Senegalia senegal*, *Anogeissus leiocarpa*, *Combretum collinum*, *Lonchocarpus laxiflorus* and *Zizphus spina-christi* were randomly distributed and this may have attributed to that these species adapted to site properties of both stands especially soil, in addition to ability of its seeds dispersal by man and animals and easy regeneration.

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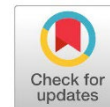
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Research Article

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The causes of Clinical and Subclinical Pathogenic Mastitis and anti-bacterial Resistance in Milk of Dairy Cows in and around Shahat, Libya

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Abstract: Overall, 200 milk samples were collected from January 2018 to March 2020, which led to the isolation of 126 pathogen agents (63%). *Escherichia coli* 46 (36.5%), *Streptococcus pyogenes* 31 (24.6%), and *Staphylococcus aureus* 19 (15%) were specified as the larger causative agents of clinical mastitis. While *Streptococcus dysgalactiae* 21 (16.7%) were mostly implicated in subclinical mastitis. With that, in both types of mastitis, also about 4 (3.2%) positive cases were caused by other bacterial agents that were identified at a low frequency (<4%) and cannot be considered as important pathogens like (*Klebsiella* spp) or non-contagious like (*Corynebacterium* spp.). The antimicrobial resistance was moderate in the total proportion; exclude penicillin in *Staphylococci*, and tetracycline in *Streptococci*, which are used as antimicrobial drug for humans' treatment in Libya. In addition to collection the date information about mastitis issue in Libya.

Keywords: antibacterial resistance, Shahat, Mastitis, Dairy Cows.

المسببات المرضية لالتهاب الضرع الظاهري والصامت للأبقار الحلوب في مدينة شحات وضواحيها

المستخلص: من إجمالي 200 عينة حليب جمعت في الفترة ما بين يناير 2018 إلى مارس 2020 تم عزل 126 عينة مصابة بالتهاب بكتيري بنسبة (63%). (مقسمة كالتالي: كأكثر عامل مسبب لالتهاب الضرع السريري وهي:

Escherichia coli 46 (36.5%), *Streptococcus pyogenes* 31 (24.6%), and positive *Staphylococcus aureus* 19 (15%). *Streptococcus dysgalactiae* 21 (16.7%). 21%) كانت المسبب الأكبر في التهاب الضرع الإكلينيكي. مع ذلك، وفي كلا النوعين من التهاب الضرع، تم أيضاً عزل 4 حالة إيجابية من عوامل بكتيرية أخرى والتي كانت بنسبة منخفضة، وبالتالي لا يمكن اعتبارها مهمة مثل *Klebsiella* spp أو غير معدية مثل *Corynebacterium* spp. وكانت مقاومة البكتيريا للمضادات الميكروبية معتدلة في إجمالي العينات إلا penicillin وكذلك tetracycline في *Streptococci* وفي *Staphylococci* النسبة وإن كانت ليست عالية إلا أنها تهدد الصحة العامة ويرجع أهمية هذه المضادات الحيوية إنها تستخدم في علاج البشر بالإضافة إلى أنه يجب التنويه إلى أن المعلومات حول مشكلة التهاب الضرع في ليبيا ضعيفة.

الكلمات المفتاحية: المسببات المرضية، التهاب الضرع الظاهري والصامت الأبقار، مدينة شحات.

INTRODUCTION

Mastitis, the most common infection or inflammation of the mammary gland in dairy cows, is known to have a negative impact on both the welfare of the animals and the financial success of dairy farms. Since the advent of contemporary dairy farming, farmers have looked for practical



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ways to reduce the risk of mastitis in their herds (Ruegg, 2017). Clinical and subclinical mastitis, which is responsible for one of the most common diseases affecting cows worldwide, causes a big economic problem. Many bacterial pathogens induce udder inflammation, which in the case of mastitis results in an increase in leukocytes or somatic cell count in the mammary gland in response to microbes invading the teat canal, multiplying, and producing toxins that harm milk-secreting tissue as well as the mammary gland's various ducts. The procedure yields less milk and different milk composition with a higher concentration of leukocytes or somatic cells (Ahmed et al., 2020).

Before treatment with antibiotic, it is necessary to reduce the somatic cell count (SCC) and the antimicrobial resistant test. Unfortunately, almost all veterinarians don't do that before choosing the antibiotic. One source of the reinforced occurrence of resistant bacteria is the inexperienced and excessive use of antibiotics in veterinary medicine. The wrong choice or small dose when using antibiotics to treat mastitis in dairy cows causes a big problem with antimicrobial resistant bacteria (Ahmed et al., 2020; Li et al., 2016).

Multidrug-resistant isolates of different bacterial species were confirmed via antimicrobial resistant tests as well as the detection of the type and incidence of antimicrobial resistance. Although many of the tests discussed are of value in detecting the presence of acute to sub-acute mastitis, isolation and identification of specific microorganisms from milk is usually. Udder infections with *Staphylococcus aureus*, *Streptococcus dysgalactiae*, and *Streptococcus uberis* are common causes of bovine mastitis (Li et al., 2016).

Over all 126 pathogens have been isolated from milk for bovine mastitis, which are classified as chronic, acute or sub-acute mastitis. Most causes of bacterial mastitis in this study were designed to detect the type, concentration of bacteria, and their antibacterial resistance isolated from milk to clinical or subclinical mastitis cows in this region.

MATERIALS AND METHODS

Sampling collection:

A total of 200 milk samples were divided into two sets of milk from clinical (100) and apparently healthy cow (100), collected and tested using the culturing method to detect the bacterial agents that cause clinical and subclinical mastitis. According to National Mastitis Council guidelines and the Dairy Cattle Herd Selection, milk samples were taken after washing and drying the udder (S. P. Oliver & National Mastitis, 2004). Teat ends were disinfected with cotton swabs soaked in 70% ethanol. The first few streams were discarded. Approximately 10 mL of milk from each udder quarter was put into sterile tubes. Samples were transported to the laboratory in an ice box and stored at 40 C for subsequent bacteriological analyses. Samples were collected according to (Reyher et al., 2011) with some modifications. Different sets of milk from (Ruegg, 2017) cows with clinical mastitis (M1 to M3), (Ahmed et al., 2020) apparently healthy and lactating cows were divided into cows before drying-off (BD) and after calving (AC).

All producer-diagnosed clinical mastitis cases were sampled (M1), as shown (Table 1). The M1 samples were taken before antimicrobial treatment, whereas the M2 and M3 samples were taken after antimicrobial treatment. All samples until use were saved at -20°C in deep freezing. Clinical mastitis was defined as an inflammation of the udder leading to the occurrence of flakes, clots, or other gross alterations in milk, whereas subclinical mastitis was defined as SCC >200,000 cells/ mL from a cow without clinical signs of mastitis (S. Oliver & Calvino, 1995).

Table: (1). Divided of milk sample according to symptoms of mastitis

Sy	Healthy condition	Antimicrobial treatment	s-n
M1	Cows with sever clinical mastitis	Taken before antimicrobial treatment	35
M2	Cows with moderate clinical mastitis	Taken after antimicrobial treatment	32
M3	Cows with chronic clinical mastitis	Taken after antimicrobial treatment	33
AC	Apparently healthy and lactating cows after calving	Taken without antimicrobial treatment	50
BC	Apparently healthy and lactating cows before dry-off	Taken without antimicrobial treatment	50

Laboratory examination:**Somatic cell count (SCC):**

SCC $\leq 150,000$ Cells /ml normal $>150,000$ to $\leq 200,000$ cells/ml suspected and retested. Subclinical mastitis was defined as SCC $>200,000$ cells/ mL (S. Oliver et al., 1995).

Detection of bacterial agents:

Bacterial culturing and identification of the milk samples were done according to National Mastitis Council guidelines (Hogan et al., 1999). The bacterial agents were isolated on MacConkey agar and blood agar. Thin stained Gram stains were used to Characterize gram-positive cocci (*Streptococcus pyogenes*, *Streptococcus agalactiae*, *Streptococcus dysgalactiae*, *Staph. aureus*), small single gram negative cocci non motile (*Corynebacterium*) and gram negative rods (*Escherichia coli* and *Klebsiella* species).

On blood agar, the identification of *Streptococcus* and *Staphylococcus aureus* showed that all *Streptococcus spp* are urea test positive, mannitol fermentation positive, Coagulase, Catalase negative and between *Streptococcus spp* Clam F, TSI. T, Voges-Proskauer test, Citrate and Sodium hippurate test between *Streptococcus galactiae*, *Streptococcus dysgalactiae* (Table 2). on MacConkey agar were identified as *E. coli*. *Klebsiella* species isolates were positive to Voges Proskauer test, non-motile, negative to indole production, produced urease, negative to both the Methyl red and utilized citrate tests (Table 3).

Table: (2). Identification of cocci bacteria

	G. S	Clam F	Coag	TSI	U T	Ca	C	L .F	MT	V R	Sodium hippurate
<i>St. aur</i>	+Cl.co	+	+	+	-	+	+	+	-	+	-
<i>S. Py</i>	+str. co	+	-	+ G	+	-	-	+	+	-	-
<i>S. dys</i>	+str.co	-	-	+	+	-	+	+	+	+	-
<i>S. a</i>	+str. co	-	-	+ G	+	-	-	+	+	-	+
<i>C. b</i>	- co	-	+	+	-	-	-	-	-	-	-

G S: Gram stains, TSI: a triple-sugar iron agar slant, U: a urea, C: citrate, V.P: Voges Proskauer, M: motile, L F: lactose fermenters, SA: staphylococcus aureus, S. Py: Streptococcus pyogenes, Streptococcus galactiae: Sa, Streptococcus dysgalactiae: Sdys, Klebsiella ssp: K. ssp, Cb: Corynebacterium.

Table: (3). Identification of rod bacteria results by biochemical tests

Rod bacteria	I T	MR T	C T	V-P T
<i>E.coli</i>	+	+	-	-
<i>Klebsiella species</i>	-	-	+	+

Indole production (I.T) test, Methyl red (MR) test, Citrate Utilization (C T) test, Voges-Proskauer (V-P) test.

Antimicrobial resistant Test (ART):

It was conducted on a Mueller Hinton Agar plate contained antimicrobial discs that are commonly used for mastitis prevention and control, and those included: Oxytetracycline, Ampicillin, Amoxicillin, Penicillin, Gentamicin, Tetracycline, Ceftiofur, Cephaloxhine and Sulfadimethoxine

RESULTS AND DISCUSSION

A total of 200 samples were examined by SCC techniques. 130 samples were positive, but only 126 (63%) were positive by microbial examination in cases of clinical and subclinical bovine mastitis with a P Value of (0.001-0.02). This difference may be due to birth and lactation, especially since the positive samples were after the lactation period and were not bacterial infections of the udder. While it was positive by microbial examination, only 100 (50%) were positive for Clinical mastitis and 26 (13%) were apparently healthy cow. The most prevalent bacterial mastitis types detected are *Escherichia coli*, *Streptococcus pyogens*, *Streptococcus dysgalactiae*, *Staphylococcus aureus*, *Streptococcus agalactiae*, *Klebsiella* spp and thin *Corynebacterium* spp nearly (see Table 4 and Figure 1). These partly agreed with the data of (Ahmed et al., 2020) who found *Staphylococcus* are high prevalent bacterial agent than this research.

Table: (4). Bacteriological Findings on the milk sample

Bacterial species	Sub clinical mastitis	Clinical mastitis	Percentage %	P.v
<i>E.coli</i>	8	34	33.333%	0.005
<i>Strep- pyo</i>	3	28	24.603%	0.025
<i>Strep- dys</i>	9	12	16.666%	0.05
<i>Staph- aureus</i>	4	15	15.079%	0.01
<i>Strep- ag</i>	2	7	7.140%	0.01
<i>K-spp</i>	0	2	1.587%	0.005
<i>C b,</i>	0	2	1.587%	0.005
Total ve+	(13%) 26	(50%) 100	(63.0%)	

Results revealed that Positive milk samples according to symptoms of mastitis were found in cows with sever clinical mastitis (M1) (35) Ve+, and the high positive number was *E. coli* 18, cows with moderate clinical mastitis (M2) (32) Ve+, and *Staph. aur* was high 14, 25Ve+cows with clinical mastitis (M3) *S.py* (9) Ve+ ,(12) Ve+ apparently healthy and lactating cows after calving (AC)in *S. dys* with (10) Ve+ and (22) Ve+ apparently healthy and lactating cows before dry-off (BD) in *S.dys* with (9) Ve+ (see Table 5) .

E. coli represented the highest presence in the result. It may be that these bacteria are naturally found in feces of animals and therefore a source of infection. *Staphylococci* are major causative agents of clinical or subclinical bovine mastitis and generate important losses in the dairy industry. Other previous studies have confirmed that *Staph. aureus* and *Str. agalactiae* were the most prevalent causative agents of mastitis (Elsayed & Dawoud, 2015; Hamed & Ziatoun, 2014).

Table: (5). Positive milk samples according to symptoms of mastitis

Sy	Ve+	T.S	<i>S.py</i>	<i>S.ag</i>	<i>S.dys</i>	<i>K</i>	<i>E.coli</i>	<i>C.b</i>	<i>St. aur</i>	%	P.V
M1	35	35	10	3	2	1	18	1	0	87.5%	0.015
M2	32	32	9	1	0	0	8	0	14	80%	0.01
M3	33	33	7	1	10	0	14	0	1	62.5%	0.02
AC	14	50	4	2	8	0	0	0	0	24%	0.025
BD	12	50	1	2	1	1	2	1	4	44%	0.01

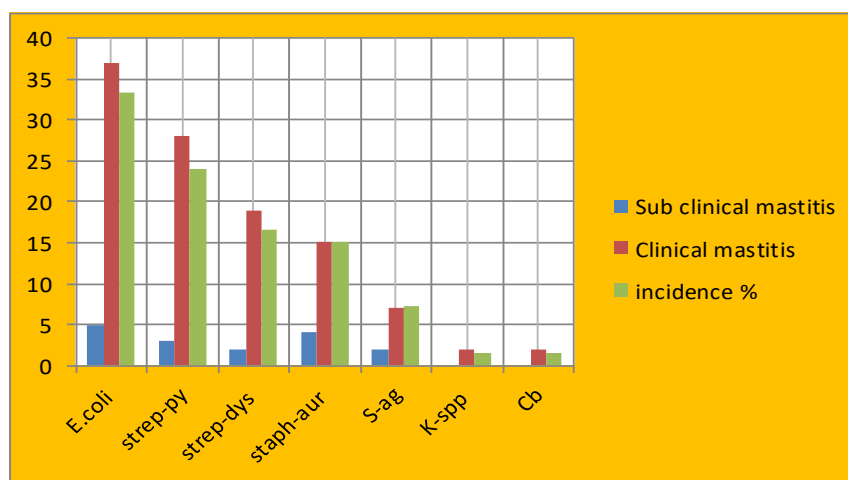


Figure: (1). Bacteriological Findings on the milk sample

The highest percentage of sensitive antibiotic was Ceftiofur (82%), followed by Cephalexin 86%, then penicillin (65%), and low prevalent were Tetracycline (37.3%), ampicillin and Sulfadimethoxine (30%). This finding nearly agreed with the data of (Ahmed et al., 2020), which found high resistance to ampicillin. Depending on the results, when AMR techniques were used to detect antimicrobial resistance, almost all positive mastitis milk samples were resistant. *Streptococcus pyogenes* was the most predominant antimicrobial resistant bacteria, with a resistant rate of 54% followed by *Streptococcus dysgalactiae* and *Streptococcus agalactiae*, which had a resistant rate of (47%).

Nonetheless, *Escherichia coli* exhibited the lowest percentage of resistance to antibiotics (25%); conversely, *Escherichia coli* was more common than the other bacteria (33.33%). *Streptococcus pyogenes* had a resistance rate of 54% to almost all antibiotics. A significant proportion of the non-*Streptococcus pyogenes* isolates (76.6%) and *Streptococcus pyogenes* isolates (24.6%) exhibited phenotypic resistance to sulfadimethoxine (70%) compared to ampicillin (63%), tetracycline (63%) and penicillin (35) (refer to Table 6, Figure 2). Egypt was found to have a high prevalence of penicillin-resistant bacteria in penicillin-resistant *staphylococci* (Awad, Ramadan, Nasr, Ateya, & Atwa, 2017), China (Qu et al., 2019) and Brazil (da Costa Krewer et al., 2015). Polish *Streptococcus* isolates produced similar outcomes (Kaczorek, Małaczewska, Wójcik, Rękawek, & Siwicki, 2017). Since amoxicillin is the most often prescribed and utilized antibiotic for the treatment of staphylococcal mastitis, resistance to these antibiotics is crucial. The overuse of antibiotics in the treatment of mastitis can be the cause of the rise in penicillin and amoxicillin resistance

Table: (6). Positive antimicrobial sensitive bacteria

Spp	Tet	Pen	Oxa	Ge	Cef	Cep	Sul	Amp	Am	P.V	Re/Bac
<i>E.coli</i>	17	9	6	6	3	11	18	19	5	0.01	%25
<i>S. pyo</i>	23	18	15	13	7	21	26	21	7	0.01	%54
<i>K</i>	1	1	0	1	1	0	1	1	1	0.02	%39
<i>S. a</i>	7	3	5	3	4	3	4	5	4	0.001	%47
<i>S.dys</i>	15	7	9	2	3	11	18	20	5	0.025	%47
<i>C.b</i>	1	1	0	1	1	0	1	0	1	0.01	%33
<i>St. aur</i>	15	7	1	1	3	10	20	17	3	0.01	%45
Res/N	79	44	36	27	22	56	88	83	26		
Res%	63	35	29	29	18	32	70	66	21		
Sen/N	47	82	90	89	104	70	38	43	100		
Sen%	37	65	71	71	82	68	30	34	79		

AMP: ampicillin, PEN: penicillin, TET: Tetracycline, Cef: Ceftiofur, Cep: Cephaloxhine, Sul: Sulfadimethoxine AMX: amoxicillin, Gen: Gentamicine, OXA: Oxytetracycline.

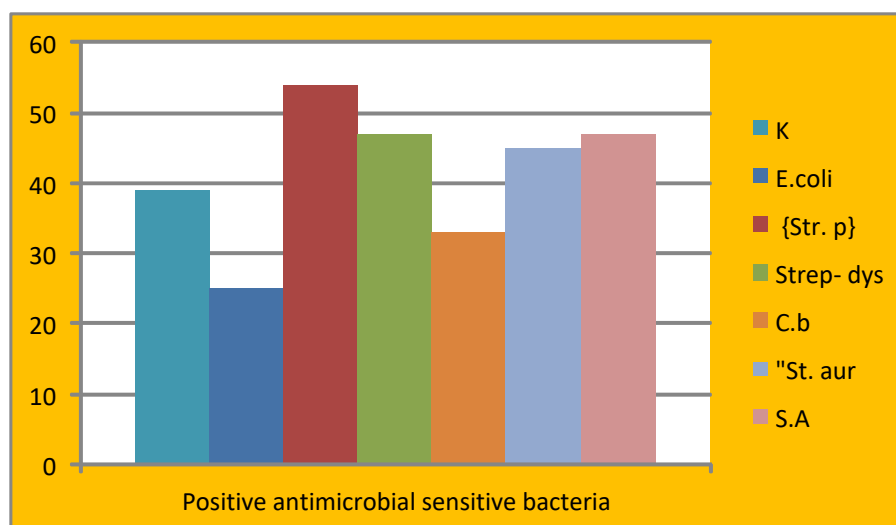


Figure: (2). Positive antimicrobial sensitive bacteria

CONCLUSION

The obtained results demonstrated the importance of studies of pathogenic mastitis in Shahat region, which is associated with weakness, decreased milk production and sometimes loss of calf. This study provides baseline information about the status of the pathogenic udder inflammation in cattle in Shahat, Libya. Also, this study highlighted the importance of awareness of the antimicrobial resistant, especially among veterinary workers when using antimicrobial drugs, the treatment of dairy cows, and their impact on the human population.

Since amoxicillin and penicillin are the most commonly used antimicrobial drugs in human medicine, their controlled use as antimicrobial agents for the treatment of mastitis is crucial. Effective veterinary care and regular epidemiological monitoring regarding antibiotic-resistant bacteria that used to treat dairy cow mastitis are recommended. This calls for a decrease in the use of antibiotics, antimicrobial medication use training for farmers and veterinarians, diagnosis before therapy, and, last but not least, pasteurization of milk. Governmental surveillance instruments can also aid in lowering the use of antibiotics.

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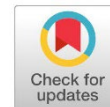
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Research Article

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Impact of a single dose of Doramectin on Hematological and Biochemical parameters in goats

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Abstract: The present study was conducted to evaluate the effect of a single dose of doramectin a number of hematological and biochemical parameters in goats. Twenty goats were equally divided into two groups, each of 10 goats. The control group was kept without any medication. While, the treated group received a single dose of doramectin at a dose level of 1 ml per 33kg of body weight subcutaneously after two and four weeks from the beginning of drug administration blood samples were collected via the jugular vein from the control and treated groups. The results demonstrated that red blood cell (RBC) counts, hemoglobin concentration (Hb %) and White blood cell (WBC) counts were significantly ($p < 0.05$) decreased in treated groups at weeks 2nd and 4th weeks as compared to the control group. While serum levels of albumin were significantly ($p < 0.05$) increased in treated goats in comparison with the control at 2nd and 4th weeks of the experiment. However, there were non-significant changes in packed cell volume (PCV%), globulin and total protein levels in the treated group as compared with the control at all the experiment period. Thus, the therapeutic dose of doramectin can induce minor changes in some blood parameters in goats. packed cell volume (PCV%) was changed with non-significant at week 2 and week 4 in the treated group compression to the control group. White blood cell (WBC) counts decreased in all groups treated from the onset to the end change in both the time treated goats at 2 and 4 weeks compared with the control group. Thus, the therapeutic dose of doramectin can induce minor changes in some blood parameters in goats.

Keywords: Doramectin, hematological, some biochemical parameters.

تأثير جرعة واحدة من الدورامكتين على المعايير الدموية والبيوكيميائية في الماعز
المستخلص: الدورامكتين هو عقار مضاد للطفيليات الداخلية والخارجية ويستخدم في الحقل البيطري على نطاق واسع للقضاء على الديدان الداخلية والطفيليات الخارجية في اغلب الحيوانات المزرعة. قمنا بأجراء هذه الدراسة لمعرفة تأثير الجرعة العلاجية على بعض المعايير الدموية والبيوكيميائية في الماعز خلال اسبوعين ثم اربعة اسابيع من المعالجة بهذا العقار. وخلال التجربة تم استخدام عدد عشرين من الماعز بأوزان من 25 الى 35 كجم وبمعمّر ما بين سنة الى سنتين وقسمت بالتساوي الى مجموعتين كل مجموعة تحتوي على عدد عشرة من الماعز اخذت المجموعة المعالجة جرعة واحدة من عقار الدورامكتين بمعدل 1مل لكل 33 كجم وزن جسم تحت الجلد في حين لم تتلقى المجموعة الاخرى اي جرعة ووضعت كمجموعة ضابطة وتم جمع عينات الدم من الوريد الوداجي بعد اسبوعين وأربع اسابيع من بداية التجربة. اظهرت النتائج الدموية بان هناك تغيرات ملحوظة متمثلة في انخفاض عدد الخلايا الدم الحمراء وتركيز الهيموجلوبين في المجاميع المعالجة عند الاسبوع الثاني والرابع من التجربة مقارنة بالمجموعة الضابطة أما بالنسبة لحجم الخلايا المرصوصة حدث تغير غير معنوي عند الاسبوع الثاني والرابع من التجربة مقارنة بالمجموعة الضابطة وايضا لوحظ انخفاض في اعداد الخلايا الدم البيضاء في المجموعة المعالجة من بداية التجربة والى نهاية التجربة مقارنة بالمجموعة الضابطة أما بالنسبة للتغيرات البيوكيميائية فقد لوحظ ارتفاع في مستوى الالبومين معنويا عند الاسبوع الثاني والرابع من التجربة مقارنة بالمجموعة الضابطة ولم يكن هناك تغير معنوي في مستويات البروتين الكلي والجلوبولين في المجموعة المعالجة في الاسبوع الثاني والرابع من التجربة مقارنة بالمجموعة الضابطة. ويستخلص من هذه الدراسة ان إعطاء الدورامكتين كجرعة علاجية في الماعز أدى الى حدوث تغيرات طفيفة في الدم ونحن نوصي بالتقيد بإعطائه جرعة واحدة في الشهر وعلى حسب وزن الحيوان.
الكلمات المفتاحية: الدورامكتين، الهيموجلوبين، الالبومين، الدم.



INTRODUCTION

Doramectin is an effective drug against the main gastrointestinal and pulmonary parasitic roundworms, such as *Dictocaulus spp.*, *Haemonchus spp.*, *Cooperia spp.*, *Ostertagia spp.*, and *Trichostrongylus spp.* Additionally, multiple myiasis (caused by screwworm, bot, and warble flies) (Anchordoquy et al., 2019). A previous article stated that the most often used anti-parasitic medications in the veterinary profession are macro lactones, specifically avermectins, which have fundamentally changed procedures aimed at controlling parasites and have annual sales exceeding one billion US dollars (Salman et al., 2022). The effects of eprinomectin and ivermectin on *Triatoma infestans* blood supply behaviour. (Dadé et al., 2017).

The adverse effects of the three insecticides in the study have been shown through prior studies. An interesting supplement tactic to the use of pyrethroids for the management of *Triatoma infestans* is the recorded administration of ecto/endoparasiticides to domiciliary or peridomiciliary animals. (Dadé et al., 2017). According to a study doramectin, antiparasitic effect results from inhibition of gamma-aminobutyric acid (GABA) neurotransmission. (de Souza Spinosa et al., 2000). Anxious and seizures constitute two behavioral manifestations that may be related to GABA-ergic neurotransmission. Similar to anxiolytic drugs, rats administered Doramectin (100,300 and 1000 ug/kg, S/C) had no effect on their capacity to move around or rear, although the amount of head dipping increased enhanced. (Santos et al., 2017).

In the plus-maze test, doramectin recorded that *Psoroptes ovis* and *Leporacarus gibbus* could be effectively controlled with a single oral dosage of 200µg/kg (Santos et al., 2017) A semi-synthetic macrocyclic lactone called doramectin is derived from the fermentation byproducts of soil microbes such as *Streptomyces avermitilis*. Its characteristics are fairly comparable to those of ivermectin (Bowman, 2004). High efficacy against a broad range of internal and exterior parasites is a hallmark of *avermectins*. They are generally highly safe medications for use in mammals due to their manner of action (Courtney & Roberson, 2001). It is also active against most mites, ticks, lice species and against *numeous myiasis* (e.g. those caused by screw worm flies, bot flies and warble flies). However, the commonly used anti-parasitic drugs cause many side effects on the different organs of treated animals, such as transient irreversible neuromuscular blockade and hypertension (El-sawy, 1983; Rosseff., 1974). The aim of this study is to evaluate the effect on a number of hematological and biochemical of the single dose of doramectin (1ml/33kg b.w. s.c) administered subcutaneously to goats.

MATERIALS AND METHODS

Doramectin

(Doramax)®1% is an injectable solution produced by Vemedim Company. Each milliliter contains 10mg/ml. All the diagnostic kits used for assaying the hepatic (total serum protein, serum albumin and globulin) were obtained from Bio-diagnostic Company, Egypt. Other chemicals for hematological studies (RBCs and WBCs counts, hemoglobin percentage and packed cell volume value tests) were performed by an automatic blood cell analyzer (XP-300). (Automated Hematology Analyzer, Sysmex American).

Experimental design

Animals

Twenty goats aged 1-2 years old (average body weight 25-35 kg) were obtained from Bodloma farm. The animals were kept under standard conditions inside the barn for 2 weeks and ensured free from any infection. They had no limitations to drinkable water and often –scheduled foods.

First group: control group (no any treatment was used).

Second group: injected doramectin (1ml/ 33 kg. b. w. s c.) a single dose. The blood samples were collected from all animals at the second and fourth weeks for hematological and some biochemical parameters.

Statistical analysis

The data were analyzed by using independent samples T- test. There were two groups, first group was the control group and second group was ZONPs treated group. Data were analyzed by using SPSS, 23. The significant effect was set at ($P < 0.05$). Data were presented as mean $\pm$ standard error.

RESULTS

Hematological findings

The results showed that red blood cell (RBC) counts, hemoglobin concentration (Hb %) and White blood cell (WBC) counts were significantly ($p < 0.05$) decreased in treated groups at 2nd and 4th weeks as compared to the control group. However, Packed cell volume (PCV%) showed non-significant changes at 2nd and 4th weeks as compared to control throughout the experiment period.

Biochemical findings

The results demonstrated that serum levels of albumin were significantly ($p < 0.05$) increased in the treated goats compared with the control at 2nd and 4th weeks of the experiment. However, there were non-significant changes in globulin and total protein levels in the treated group as compared with the control throughout the experiment period.

Table:(1). The effect of doramectin (1ml/33kg .b. w .s. c) on hematological at 2 and 4 weeks in goats from drug administration compared to control (Mean $\pm$ SEM).

Parameters	Control (Mean $\pm$ SEM)	After2 week (Mean $\pm$ SEM)	After4 week (Mean $\pm$ SEM)
PCV(%)	35.50 $\pm$ 02.10	35.48 $\pm$ 02.00	35.29 $\pm$ 02.00
Hb (g/dl)	12.06 $\pm$ 00.26	11.02 $\pm$ 00.22*	11.80 $\pm$ 00.20*
RBCs (X10 ⁶ / μ L)	8.60 $\pm$ 0.50	7.30 $\pm$ 0.20*	7.90 $\pm$ 0.10*
WBCs (10 ³ / μ L)	8.80 $\pm$ 0.75	7.20 $\pm$ 0.60*	7.80 $\pm$ 0.80*

*Mean with different superscripts between rows refer to significant ($p < 0.05$).

Table:(2). The effect of doramectin (1ml/33kg .b. w .s.c) on levels of total protein, albumin and globulin at 2 and 4 weeks in goats after drug administration compared to control (Mean $\pm$ SEM).

Parameters	Control (Mean $\pm$ SEM)	After2 week (Mean $\pm$ SEM)	After4 week (Mean $\pm$ SEM)
Total protein (g/dl)	8.20 $\pm$ 00.55	8.15 $\pm$ 00.40	7.96 $\pm$ 00.32
Albumin (g/dl)	3.80 $\pm$ 00.31	4.01 $\pm$ 00.40*	3.90 $\pm$ 00.40**
Globulin (g/dl)	4.17 $\pm$ 00.50	4.15 $\pm$ 00.35	4.00 $\pm$ 00.20

*Mean with different superscripts between rows refer to significant ($p < 0.05$).

DISCUSSION

Avermectins are considered very safe drugs in ruminants. (Sas, 2002). The aim of the current investigation was to evaluate the impact of a therapeutic dosage of doramectin on a number of hematological and biochemical parameters in goats. Prior to the trial, the majority of the goats' hematological and biochemical parameters were within normal physiological ranges. Various studies have different normal values (Jazbec, 1990 ; Kaneko, 1997). The results obtained aligned with the study, which found doramectin reduced trends in hemoglobin, red blood cells, and platelet count relative to pre-experiment values (Zhang et al., 2019). Moreover, the results obtained on W.B.C, counts in treated goats showed a decreased in W.B.C counts, at 2nd and 4th weeks of the experiment. The obtained results are compatible with those reported. (Jadhav et al., 2017). where they found that the

hematology of bullock drenched with 200 ml. of the anthelmintics suspension of oxcyclozanide in combination with levamisole revealed severe leukocytosis (19.20×10^9 /L), lymphocytosis (9.80×10^9 /L), neutrophilia (8.70×10^9 /L) and thrombocytopenia (28×10^9 /L). The same study also noted that leukocytosis with neutrophilia, lymphocytosis, and thrombocytopenia were found in the hematology (Jadhav et al., 2017). Clinical recovery began on the second day of treatment due to the combination of one slow acting and one rapid acting compound; however, five days of treatment were needed for full recovery. Thus, supportive care and patient observation may be used to treat such cases of concurrent anthelmintics poisoning in farm animals. The hemato-biochemical investigation results are consistent with those published by (Shrimali et al., 2016), Researchers noticed that the groups treated with anthelmintic showed significantly increased hemoglobin, total erythrocyte counts, pack cell volume and total protein compared with the control group.

CONCLUSION

It could be concluded that therapeutic dose of doramectin in goats can induce minor changes in blood, we recommend administering a single dose during the mouth and according to the weight of the animal.

Duality of interest: The author declare that they have no duality of interest associated with this manuscript.

Author contributions: The author did all the work related to the manuscript.

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