Misr J. Ag Eng. 19 (2) : 401 – 408

Evaporative Cooling by using Palm Fibers Pad in Poultry buildings

By

*I.S.EL-soaly

Abstract

At the present time , the poultry buildings for meat production are wide spread across Egypt, to meet the needs of the increasing population. Design of a proper poultry building requires scientific knowledges about building construction and environmental control for improving the performance of productivity. The poultry production is affected by the environment inside the building which includes: temperature , humidity , air velocity, light and gases. The goals of suitable temperature and humidity inside the building are: increase the poultry production , decrease electricity consumption and decrease treatments costs. The height of temperature in summer is a great problem in poultry buildings; so the temperature must be decrease. The experiment was conducted in two similar broiler buildings located at Roda city, Farscor center, Dameitta Governorate. Each building size was 10.5 m length,7 m width and 3 m height, the first building provided with an evaporative cooling pad (PF). The cooling pad dimensions were 2.5 m length (window length),0.75 m width and 0.075 m thickness. There was three exhausted (0.45x 0.45 m) fans located on the other side (wall) of first building .The air velocity rear the pad was minimum 1 m/s up to 3 m/s maximum. The objectives of the present work are; evaluating and testing the evaporative cooling pad (PF). Compared between the two buildings (temperature, humidity and electric consumption). The building one have given the best results as it reduced the THI by 5.04 C° and 6.48C ,i.e. 14.42 and 18.56%, η for evaporative cooling with mean 85.08%, increased the relative humidity with mean 24.44% and decreased the temperature with about 7C . The farmers can be used PF pads to decrease indoor temperature in broiler building. An electric consumption was 33 KW/day through study period. A unit of pad for a window costs about thirty pounds.

Introduction

. In order to protect the poultry inside the building from high temperature (in summer) ; farmers reduced number of birds in meter square, clean a part of breeding area and put an ice on it to comfort the birds , droped canvas on the windows which obstructed the natural ventilation, and used fogging nozzles; but this system increased respiratory diseases. So we try to answered on this problem by using Palm Fibers Pad. Indeed evaporative cooling is consider as the most reliable system for broiler buildings. In the meantime, there are some difficulties whether its meteorological, engineering or pad material properties such as; ambient air temperature, ambient air relative humidity, some research work done by Abdel-Rahman.(2000)said that, the air temperature depletion (8c .as a maximum) in his study for the comparison between aspen wooden fiber and long wheat straw as evaporative materials for greenhouse cooling systems. Wilson et al .(1983)found that the evaporative cooling with fogging nozzles in broiler houses could lower dry- bulb temperature in the houses by 3.3 to 4.4 °c, and they found that it was not necessary to reduce bird numbers during the summer .They also found that, broiler body weight and feed conversion can be improved in house where evaporative cooling is used , and mortality rates can be lowered in evaporative cooled houses compared to uncooled houses. Welchert et al. (1975) said that, the optimum air velocity at the pad face is 200 (± 50) (FPM) (about 1.02 m/s (± 0.25m/s)).Canton et al .(1982) mentioned that the responses of deep body temperature and respiration rates, there is a potential for evaporative cooling to reduce thermal stress of birds in hot, humid climates. Durward et al .(1985) indicated that pad-fac air velocity above 250 feet per minute (1.27m/s)and an effective, and economical pad design would be a 3-inch (7.5cm) thick aspen excelsior pad. Timmons et al.(1981) show that the results for their study presented herein

* Lect., Agr. Eng. Dep., Fac.of Agr., AL- Azhar Univ.

were obtained for broilers, the economic justification of a continuous pad system based upon improved feed conversion is not feasible, but based upon increased weight gains, and a more justifiable installation would be where reduced production losses or mortality losses carries a higher economic penalty. e.g. Evaporative cooling system gives a good climate and a good productions . Albright(1990) reported that, the degree of saturation is a separate mean to describe the extend of saturation . The degree of saturation and relative humidity are equivalent for dry air and saturated air . Deshazer and Beck (1988) derived a relationship between temperature- humidity index (THI) and dry and wet-bulb temperature for laying hens as follow:

THI = 0.6 tdb +0.4 twb --(1)

where:

THI : temperature-humidity index.

tdb : dry- bulb temperature . C°

twb : wet- bulb temperature

Timmons and Baughman (1984) by using evaporative pads cooling system , for plenum concept , they concluded that: a

-The evaporative pads cooling efficiency were determined by using the following equation

η = ((Todb – Tcdb)/ (Todb – Towb)) x 100 ------------------------(2)

where:

Tcdb: is a dry-bulb temperature of cooled air .

Todb: is a dry-bulb temperature of outside air temperature .

Towb: is a wet-bulb temperature of outside temperature .

- By using a pad plenum concept, evaporative efficiencies of 80% can be obtained with reasonable ventilation rates while simultaneously maintaining average inlet velocities above 3m /s and average floor velocities of 0.9m/s .

Taha.(1997) said that the maximum value of evaporative pads cooling Efficiency was obtained in the afternoon period, and the minimum value of evaporative pads cooling efficiency was obtained in the morning period and at the end of the day, so the optimum period is from 12 clock to 16 clock.

The objective of this study was to compare between natural ventilation and palm fiber evaporative cooling pad.

This study covered three analysis :

- Measurements of indoor and outdoor (temperature , relative humidity ,dry and wet-bulb temperature and indoor air velocity).
- Compare between the two buildings by :
  - a - THI (temperature-humidity index).
  - b - η (the reduce of temperature efficiency).
  - c - D (difference between inside and outside relative humidity).
  - d- difference between inside and outside temperature.
  - e - Mortality.
  - f - Electric consumption .

Materials and methods

The site was in Roda, Farscor Center,Dameitta Governorate. It is located at latitude 31.4 degrees. The experiment was conducted in two buildings.

Construction of buildings under study:

a-Dimension of each building 3x7x10.5 m.

b-The ceiling was constructed of reinforced concrete with falling beams, thickness of ceiling 15cm.

c-The walls were clay red bricks. 12 cm thick of bricks, The walls were covered on both sides with 1.5 cm thick cement and sand mortar. Therefore, the total thickness of the wall is 15 cm.

d-The windows were found on both northern and southern walls. There are 6 windows of 1.25 m height and 2.5 m width. Plastic sheet of 1mm thickness was used to covered it.

e-Wooden doors were with dimensions 2.5 cm thickness, 2.2 m height and 2 m width. The building have a door at end of the building.

f-The floor of the building consisted of a 10 cm thick layer of cement concrete. The floor level was 20 cm higher than the outside level.

g-The lengthwise building orientation is East- West direction.

h-A vertical evaporative cooling pad located at the north wall in the first building. The cooling pad dimensions were 2.5m length. 0.075m width and 0.75m height. The first building have 3 pads. The air velocity rear the pads was minimum 1 m/s up to 3m/s maximum. There were three exhaust (0.45x 0.45m²)fans located in the other side of the building.

i-Every building have 1000 birds. (1 kg).

j-The two buildings were similar for treatments. (Fig.1).

Cooling Media design and properties:

In this research, the Palm Fiber (P.F) put between two wire netting , with 0.075m width , 0.75m height and 2.5m length (1.625 kg.P.F/m²). The pad was held on a wood hanger frame to support it within a wood frame. The water was drop from 12 mini-hols from tube at every 20 cm , the water was collected on hemisphrical tube on the below fram and discharge to outside. Water tank was on the ceiling of the building (1.5 m head).(Fig.2).

Evaporative material water holding capacity:

A primary experiment was done to explore the water holding capacity of the palm fiber (P.F). This pre-test experiment was based on a small sample of evaporative material (0.4kg) damped it in a bucket of water for 24 hours to ensure the maximum wetness capacity . It was taken out and left until the end of dripping . Then simply it was weighed again at different times to get the maximum water holding capacity as shown in Fig.(3).

- Measuring instruments:

1-Hygrothermograph: was used for measuring temperature and relative humidity, with an accuracy 1°c for a temperature and 1% for a relative humidity .

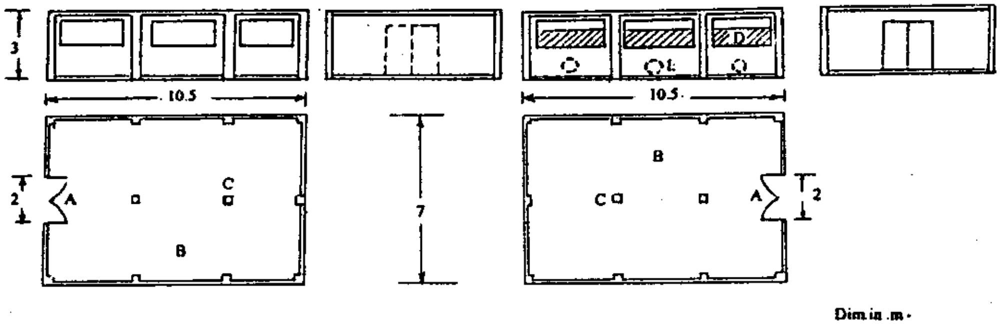
2-Compass: was used to measure buildings orientation with an accuracy of one degree.

3-Turbo Meter was used to measure wind speed with sensitivity 0.1m/s .

Methods:

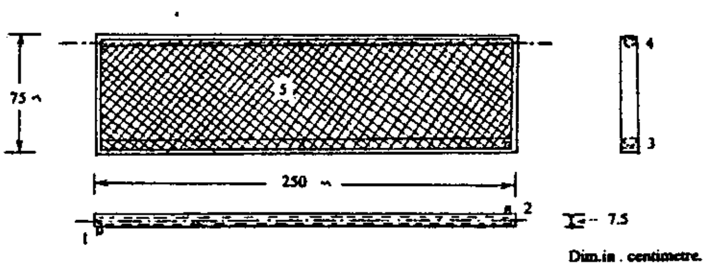
This study conducted to test the Palm Fiber pad to used in evaporative cooling in broiler building in Dameitta in hot summer . The study covered:

-Measurements of temperature and relative humidity:



A : Main door .
B: Breeding area .
C:Square section column (25x25cm²) .
D: Palm Fiber pad.
E: Exhaust (0.45x 0.45 m²) fans .

Fig.(1): The broiler buildings under study.



1- Water tube .
2- Discharge tube.
3-Collected semi tube.
4- Water distribution tube.
5- Palm Fiber (pad) between two netting.

Fig.(2): The palm fiber (P.F) cooling pad.

The temperature inside the building was measured by using a hygrothermograph at 60 cm and 120 cm height avoid damage by the chicks and the air flow (at 10 different locations). The outdoor temperature was also measured by a hygrothermograph at a height of 60 and 120 cm , also the relative humidity was measured along with the temperature. Wet-bulb temperature was calculated by Program Plus (Albright, 1990).

- Measurements of indoor air velocity :

The air velocity inside the buildings was measured by using Turbo Meter through study dates.

Compare between the two buildings by :

- THI was calculated by equation (1)
- η was calculated by equation (2).
- D ,T-R , Mortality and electric consumption were calculated.

Results and discussions

There is no doubt that evaporative cooling process was affected by climatic factors such as ; air velocity, air temperature and relative humidity, for inside the building. The derived values affecting the cooling process and related to the evaporative pad temperature and air velocity.

-Water holding capacity:

A simple primary test had been done to determine the water holding capacity for evaporative materials. Fig.(3) shows PF is holding as 526g of water, also had much better water releas rate (313g/22h). That means PF needs long time to be misted frequently.

- Depletion of the air temperature from incoming air:

In order to comparison between the two buildings { bui.1.(cooling pad) and bui.2.(natural ventilation)}.

1- Effect of evaporative pads cooling and natural ventilation on inside THI:

The mean values for the inside temperature-*Humidity* index *(THI)* were 29.92 and 34..96 C° at date 1/7, 28.44 and 31.84 C° at date 5/7 respectively for the two buildings. This indicates that the building 1 (have pads) has given the best *result* as it *r*educed the THI by 5.04 and 6.48 C°, i.e. 14.42 and 18.56 % .As show in figure (4).

2- Evaporative pads cooling and natural ventilation efficiency for two buildings :

The mean values for efficiency (η) were 78.46 and 15.3 % at date 1/7, 91.7 and 47.9% at date 5/7 respectively for two buildings. This indicate that the building 1 (have pads) has given the best result.

3- The effect of evaporative pads cooling and *natural* ventil*ation* on inside relative humidity:

The mean values for the difference between *inside* and *outside relative* humidity (D) were 9.88 and 8.54 % at date 1/7 , 16.86 and 12.48 % at date 5/7 respectively for the two buildings . This indicate that the building 1 has given the best result as it increased the relative humidity by 15.71 and 13.58 % , i.e. 28.09 and 20.79% . As show in figure (5).

4 - The effect of evaporative pads cooling and natural ventilation on inside *temperature* :

The mean values for the reduction of temperature (R.T) were 6 and 1C° at date 1/7, 8 and 4.2 C° at date 5/7 respectively for the two buildings . This indicate that the building 1 has given the best result as it decreased the temperature by 15.96 and 2.66 %, i.e. 21.16 and 11.11 %. As show in figure (6).

5-The mean work time for evaporative cooling Palm Fibers were 11.4 min./h at date 1/7 and about 15.4 min./h at date 5/7, until suitable range of the temperature. (Fig.7).

6 – The mortality were 4 and 3 birds for building one, 9 and 7 birds for building two at dates 1,5/7 respectively.

Electric consumption

In building.1.,by reading the electrometer ,and the electric consumption were on two days: 31 KW and 35 KW respectively ,with mean 33KW.

Conclusion

1- The mean reduction of temperature (R.T) were 7C° and 2.6C°at dates 1,5/7 respectively for the two buildings.

2- The mean values for efficiency (η) were 85.1% and 31.6% at dates 1,5/7 respectively for the two buildings.

3- The mean increase of relative humidity was 13.4% but, in suitable range.

4- By using THI, it found that the mean reduction of temperature-humidity index were 16.5% and 4% for the two buildings respectively.

5- The mean work time for evaporative cooling Palm Fibers were 11.4 min./h at date 1/7 and about 15.4 min./h at date 5/7,until suitable range of the temperature.

6- The work time for fans was a short time ,so the mean electric consumption was about 33KW/day.

7- A unit of cooling pad with dimensions 2.5x 0.75x 0.075 m, costs about thirty pounds.

References

Abdel-Rahman, G.M., 2000.Aspen wooden fibers and long wheat straw as evaporative materials for greenhouse cooling systems. Misr. J.Ag. Eng., 17 (3): 647- 659 .

Albright,.L.D.,1990. Environmental Control for Animals and Plants- American Society of Agricultural Engineers, Library of Congress Catalog Card-number 90- 062260 international standard book Number 0-929355-08-3.

Ashour,T. H.,1997.Environmental Studies For Broiler Houses Of Kaliobia Governorate. .Sc.Thesis Agr.Eng.Dept.College of agriculture (Moshtohor),Zagazig University., P: 81.

CIGR.,1992.2nd Report of working group on Climatization of Animal Houses, 2nd Gent, Belgium: Center for Climatization of Animal Houses-Advisory services, faculty of agricultural sciences , state Univ .of Ghent.

Conton,G.H. Buffington , D.E.and F.B. Mather, 1982. Evaporative Cooling Effects on Mature, Male Broiler Breeders. American Society of Agricultural Engineers, University of Wisconsin – Madison, June 27-30.paper No 82-4058.

Deshazer,J.A.and M.M.beck, 1988. University Nebraska report for north east Reginoal Poultry project NE-127.Agricultural research division, university of Nebraska, Lincoln.

Durward,S.Benham,Jr.and Frank Wiersma, 1985.Design Criteria of Evaporative Cooling For Agricultural Applications. ASAE, University of Arizona, Tucson, Arizona 8571. p:1-19.

Timmons, M.B. Baughman, G.R. and C.R. Parkhurst , 1981. Use of Evaporative Cooling to Reduce Poultry Heat Stress. ASAE, Palmer House Chicago, Illinois. December 15 – 18,: 1-19.

Timmons,M.B.and G.R. Baughman,1984. A plenum concept applied to evaporative pad Cooling for broiler housing. Transaction of the ASAE.31(2): 1877-1881.

Welchert,W.T.Frank Wiersma, P.E . and P.E ., 1975. Evaporative Cooling Pad Cabinet Design. Reprinted from Progressive Agriculture in Arizona , January- February, Vol. XXVII, Number 1: 6-8.

Wilson, J.L . Hughes, H.A. and W.D. Weaver, 1983. Evaporative Cooling with Fogging Nozzles in Broiler Houses . Trans. ASAE, 26(3):557-561.

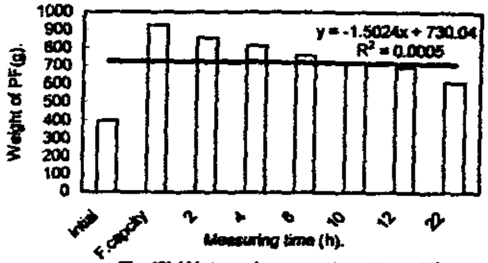


Fig.(3):Water release pattern from PF.

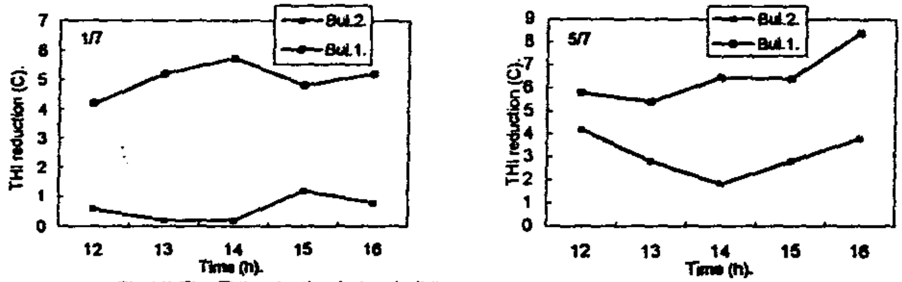


Fig.(4):The THI reduction in two buildings.

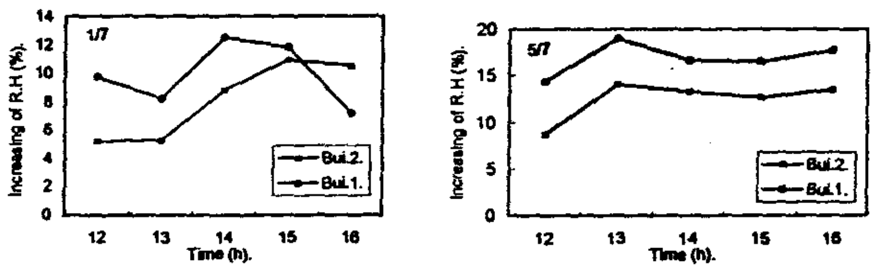


Fig.(5).Relative humidity increasing in two buildings.

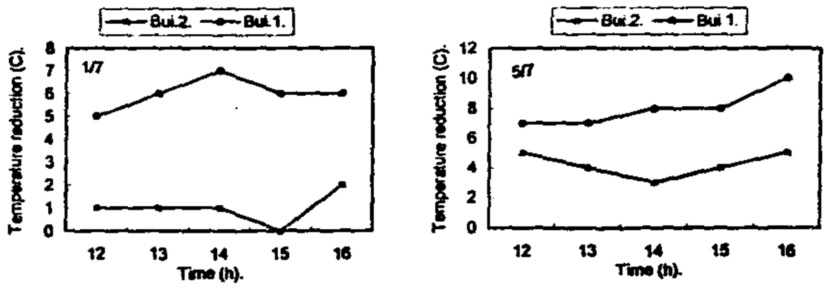


Fig (6):Temperature reduction in two buildings.

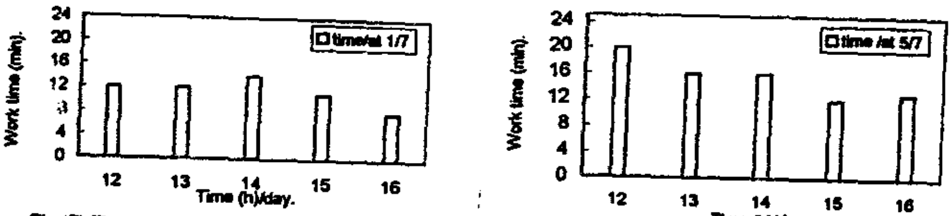


Fig.(7): The work time for evaporative cooling Palm Fibers pad at dates 1,5/7.

الملخص العربي

التبريد التبخيري في مباني الدواجن باستخدام وسادة ليف النخيل

إبراهيم سيف السوالي*

لقد أجريت الدراسة داخل مبنيين متماثلين تماما لتربية دجاج اللحم في مدينة الروضة مركز فارسكور محافظة دمياط بغرض معرفة مدى نجاح استخدام التبريد التبخيري كوسادة من ليف النخيل المتوفر لدى الفلاحين ولا يستفاد منه إلا بنسبة قليلة جدا فهو رخيص الثمن . حيث تتعرض مباني الدواجن وخاصة في فصل الصيف لموجات شديدة الحرارة قد تودي في كثير من الأحيان بحياة نسبة كبيرة من هذه الدواجن وخاصة في المباني ذات النظام المفتوح وهو الأكثر شيوعا في هذه المنطقة . ويلاحظ أن القائم بهذه التربية يقوم بمحاولات كثيرة للتغلب على هذه الحرارة المرتفعة دون جدوى مثل (تقليل عدد الدواجن للمتر المربع - إخلاء أرضية جزء كبير من العنبر من الفرشة - وضع الثلج المجروش في بعض الأماكن حيث يستريح عليه الطائر - كذلك استخدام نظام الترذيذ لقطرات الماء مما يؤدي إلى زيادة الرطوبة وبالتالي يؤدي ذلك لزيادة الأمراض التنفسية وبالتالي تزداد نسبة الوفيات - إنزال الستائر على الشبابيك مما يعوق عملية التهوية) ، كل ذلك يؤدي في النهاية إلى نتائج غير مرضية ، وكان لزاما علينا أن نحاول في إيجاد حلول لهذه المشكلة ، وبناءا عليه تم عمل وسادة من ليف النخيل كتجربة لاختبارها في خفض درجة الحرارة داخل مبنى أبعاده ١٠,٥ x٧ x٣ م - ذو التوجيه (شرق - غرب للمحور الطولي). وقد تم عمل وسادة من ليف النخيل بأبعاد ٢,٥ x٠,٧٥ x ٠,٠٧٥ م ووضعت على الفتحات للجدار في الناحية الشمالية (حيث اتجاه هبوب الرياح). وقد تم وضع ثلاثة مراوح (٠,٤٥ x٠,٤٥ م) في الناحية المقابلة للوسائد حتى يمكنها زيادة معدل سحب الهواء خلال الوسائد . وتم تغذية الوسائد بالمياه من خزان فوق سقف المبنى وذلك في المبنى الأول - وترك المبنى الثاني خاضع للتهوية الطبيعية .

وقد أوضحت النتائج المتحصل عليها ما يلي:

١- أدى استخدام الوسادة في المبنى الأول إلى خفض درجة الحرارة داخله حوالي ٧ م كمتوسط لأيام الدراسة (وهذه الدرجة كافية لخروج الطائر من المنطقة الحرجة) مقارنة بالمبنى الثاني حوالي ٢,٦ م (بتهوية طبيعية فقط).

٢- أدى استخدام الوسادة إلى زيادة كفاءة التبريد بمتوسط ٨٥,١% مقارنة بتبريد التهوية الطبيعية ٣١,٦% .

٣- أدى استخدام الوسادة في عملية التبريد لرفع الرطوبة داخل المبنى ١٣,٤%ولكن للحد المقبول، وبالتالي فإن استخدامها أدى الغرض المطلوب منها.

٤- باستخدام الدليل الحراري والرطوبي وجد أن معدل الانخفاض بمتوسط ١٦,٥% ، ٤,٥% للمبنى الأول والثاني على الترتيب .

٥- استغرق عمل وسادة التبخير حوالي ١١,٤ دقيقة/ ساعة كمتوسط خلال يوم١/٧ ، ثم يعاد التشغيل ؛ وحوالي ١٥,٤ دقيقة / ساعة ثم يعاد التشغيل مرة أخرى وذلك خلال يوم ٥/٧ . حتى الوصول لدرجة الحرارة المطلوبة .

٦- أن فترات استخدام المراوح كمساعدة لعملية التهوية فترات وجيزة، وبالتالي فإن استهلاك الكهرباء قليل (٣٣ك وات/يوم) كمتوسط في الأيام شديدة الحرارة .

٧- أمكن عمل وسادة بإطار من الخشب بأبعاد ٢,٥ x٠,٧٥ x٠,٠٧٥ م* بتكاليف في حدود ثلاثون جنيها لكل وحدة شباك مما جعلها في متناول أصحاب المزارع الصغيرة .

* مدرس الهندسة الزراعية - كلية الزراعة - جامعة الأزهر - القاهرة .