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Effect of roofing materials on housing environment and layer performance under open-shed system

(Kesan bahan bumbung terhadap persekitaran perumahan dan prestasi ayam penelur dalam sistem perumahan terbuka)

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Key words: aluminium, discomfort index, heat stress, layers

Abstrak

Satu kajian perbandingan terhadap keupayaan tiga jenis bahan bumbung aluminium, asbestos dan zink untuk mengurangkan tegasan haba pada ayam penelur bagi reban ayam sistem terbuka telah dijalankan. Ketidakselesaan persekitaran di bawah bahan bumbung tersebut telah dikaji dengan menggunakan model matematik, indeks kelembapan bebola hitam.

Dibandingkan dengan asbestos dan zink, bumbung aluminium memberi indeks ketidakselesaan yang paling rendah ketika pancaran suria tinggi. Analisis terhadap prestasi pengeluaran ayam penelur menunjukkan potensi peningkatan dalam pengeluaran telur dan berat telur. Kecekapan penukaran makanan didapati lebih baik bagi ayam yang dipelihara di dalam reban yang berbumbung aluminium. Ini bermakna bumbung aluminium lebih berkesan sebagai pelindung pancaran dalam keadaan persekitaran yang mengalami tegasan haba.

Abstract

A comparative study on the performance of three roofing sheets namely aluminium, asbestos and zinc, to minimise heat stress on the layers in an open-shed system was conducted. The environmental discomfort under these roofing materials was studied using a mathematical model, the black globe humidity index.

In comparison with asbestos and zinc, aluminium roof gave a significantly lower discomfort index during the period of high solar radiation. Analysis on production performance of layers indicated the tendency of increase in egg production and egg weight. The feed conversion efficiency was better for layers reared in the shed with aluminium roof. Results therefore indicate that aluminium is more effective as a radiation shield under heat stress environment.

Introduction

In a hot environment, heat stress is the main limiting factor to poultry production. Heat stress is the result of any combination of environmental conditions that cause the effective ambient temperature to be higher than the thermoneutral zone of animals body. Under a high degree of thermal stress, an animal will reduce its feed intake to maintain homeothermy, thus affecting productivity.

In tropical climate, the roofs of poultry houses are often not insulated. The long wave radiant heat load from the roof is

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sufficient to cause growth depression or substantial mortality of the poultry. Several environmental modification techniques can be used to reduce the severity of the heat stress condition. These include the selection of roofing materials.

Buffington et al. (1983) reported that under an open shed system, roof modification was an effective method for reducing production losses due to thermal stress. Under this system, the roof will alter the radiation balance without effecting air temperature or humidity.

Studies on various roof structures and their effects on poultry production are limited. Effects of different roof surface coatings on poultry production were studied by Oh et al. (1985). They found that a combination of bright colour coating on the top surface and dark coating underside had improved the environmental conditions, but not the production performance.

However, several studies on the effects of high ambient temperature on the production performance of layers have been conducted. Under a simulated constant temperature, egg production decreased when temperature exceeded 26–30 °C (Smith 1981). While under field conditions, 80% of the egg weight decrease was due to the heat stress when ambient temperature increased to above 26 °C. Heat stress was the main cause for the weight loss of egg shell.

Roller and Dale (1963) observed that dew-point temperature was critical for laying chickens. They concluded that increasing dew-point temperature depressed feed consumption, regardless of dry-bulb temperature.

This study was conducted to identify an effective roofing material for poultry house under hot climate. The approach was to evaluate in-house environment comfortability using the black globe humidity index and the effects of roofing materials on production performance of layers.

Materials and methods

Housing

Three types of corrugated roofing sheets namely aluminium, zinc and asbestos were used as roofing materials for three poultry (layer) houses. The houses were constructed following the conventional type of open-shed system with concrete flooring and bird-proof wire mesh as side walls. Each house measured 4.6 m wide and 9.1 m long with an average height of 2.6 m. The orientation of the houses was in eastwest elongation with both declined roof surfaces facing north-south.

Animals

A batch of 648 pullets of the Hisex brown strain were randomly selected from three groups of growing layers. Each group comprised 216 pullets which had been reared in three growing pens for 18 weeks using different roofing materials. Each group (216) was divided randomly into three sub-groups with eight replications. Nine birds were used in each replicate. They were placed into individual laying cages in houses of different roofing materials (aluminium, asbestos and zinc).

Feeding

The birds were fed with commercial feed rations. A standard feeding program for layers was followed. This comprised the starter (0–4 weeks), the grower (5–18 weeks) and the layer (19 weeks onwards) feeds. All feeds were given manually ad libitum while drinking water was made available at all times.

Data collection

The environmental parameters inside each house were monitored daily for a period of 35 laying weeks. Measurements were taken at 2-h intervals from 0800 h to 1600 h. The environmental parameters taken were the dry/wet-bulb temperature, roof temperature, black globe temperature, relative humidity and the air velocity.

The black globe humidity index (BGHI) was used to measure the thermal intensity of the environment to predict the animal discomfort and production losses (Swierstra and Van Ouwerkerk 1986). The determination of BGHI was based on various climatic variables. It is calculated as a linear function of black globe and dew-point temperatures.

$$BGHI = t_{bg} + 0.36t_{dp} + 41.2$$

Where, t_{bg} = black globe temperature (°C)

t_{dp} = dew-point temperature (°C)

The production performance of the layers was also monitored daily. The four performance parameters taken were egg production, feed consumption, egg weight and feed conversion efficiency (FCE). Weekly averages of the environmental and production performance data were computed and evaluated.

Results and discussion

Comparative assessment and evaluation are discussed according to the relevant topics as follows.

Effects on housing environment

The mean values of environmental parameters for 35 weeks of laying period under the three houses were calculated and shown in *Table 1* and *Table 2*. The environmental temperatures increased from early morning and reached their maximum values in the afternoon (1400 h).

The dry-bulb (ambient) temperature in the afternoon under aluminium roof was significantly lower than that under asbestos and zinc roofs (*Table 3).*

As of material properties, aluminium is lower in absorptivity (short wave) and emissivity (long wave) of solar radiation compared with asbestos and zinc (*Table 4*). These properties are of advantage since the upper surface of the roof will reduce the heat absorptance, while the lower surface will reduce the emittance of radiant heat on the animals.

Results showed that BGHI under aluminium roof was significantly lower ($p < 0.05$) than those of asbestos and zinc during the high ambient temperature (*Table 5*). However, there was no significant difference in BGHI during the early morning. This indicated that aluminium roof was able to

Table 1. Environmental temperatures and relative humidity under three roofing materials during the day

Roofing material	Time	Roof temp. (°C)		Globe temp. (°C)		Dew point (°C)		Humidity (%)	
		Mean	SD	Mean	SD	Mean	SD	Mean	SD
Aluminium	0800 h	25.1	1.0	24.5	0.7	23.1	0.7	93	2.1
	1000 h	31.9	1.6	28.3	0.9	24.2	0.9	84	3.6
	1200 h	35.9	2.4	30.9	1.4	24.4	0.9	75	5.6
	1400 h	36.9	2.5	31.9	1.3	24.7	1.1	71	6.8
	1600 h	34.3	2.1	31.1	1.4	24.6	1.0	72	6.3
Asbestos	0800 h	24.9	0.7	24.7	0.7	23.7	0.6	95	0.9
	1000 h	29.4	1.4	28.6	1.0	24.9	0.6	87	3.2
	1200 h	34.8	1.7	32.4	1.3	25.8	0.7	78	4.4
	1400 h	36.5	2.2	34.0	1.6	26.5	1.1	73	6.1
	1600 h	35.2	2.3	32.8	1.6	26.4	0.8	75	4.6
Zinc	0800 h	24.9	1.0	24.6	0.9	23.3	0.6	94	1.7
	1000 h	32.2	1.9	29.2	1.0	24.6	0.8	84	2.7
	1200 h	38.3	9.9	32.7	1.4	25.3	1.1	74	4.6
	1400 h	38.5	2.4	34.3	1.6	26.1	1.4	69	6.3
	1600 h	35.9	2.5	33.0	1.7	25.9	0.7	73	4.3

All values were based on weekly data over a 35-week laying period

Table 2. Average wind speed and standard deviation values inside the layer house measured at chicken level

Time	Wind speed (m/s)	SD
0800 h	0.10	0.05
1000 h	0.12	0.06
1200 h	0.31	0.25
1400 h	0.39	0.30
1600 h	0.28	0.16

All values were based on weekly data over a 35-week laying period

provide a more comfortable environment during the maximum level of thermal radiation.

Results on the analysis of radiant heat load (RHL) under different roofing materials are as shown in *Table 6* and *Figure 1*. The RHL under aluminium roof was significantly lower (504 w/m^2, $p < 0.05$) than those of asbestos and zinc (530 and 536 w/m^2 respectively) during the afternoon (1400 h). This was equivalent to 5–7% of heat stress reduction in every square meter of aluminium roof compared with that of asbestos and zinc.

As far as weathering is concerned, aluminium roof may be considered better in maintaining its effectiveness compared with asbestos and zinc. This is because zinc which corrodes fast with age, will decrease its top side reflectance thereby increasing the absorptance of direct radiation. Ageing of asbestos will induce algae formation which will in turn increase the absorptance of solar radiation as the roof turns dark.

Table 4. Solar radiation absorptivity and emissivity of three roofing materials

Roofing material	Short wave absorption	Long wave emission
Aluminium	0.32	0.10
Asbestos	0.59	0.90
Zinc	0.65	0.13

Source : Anon. (1969)

Table 3. Ambient temperature under three roofing materials during the day

Time	Temp. under aluminium (°C)		Temp. under asbestos (°C)		Temp. under zinc (°C)	
	Mean	SD	Mean	SD	Mean	SD
0800 h	24.3i	0.7	24.6i	0.6	24.2i	0.7
1000 h	27.3h	1.0	27.2h	0.7	27.8g	0.8
1200 h	29.5f	0.9	30.2e	1.0	30.6d	1.2
1400 h	30.8d	1.1	32.0a	1.2	32.3a	1.2
1600 h	30.4e	1.2	31.5c	1.2	31.6c	1.2

a,c,d, = Values within row with the same letters are not significantly different ($p < 0.05$) based on DMRT

Table 5. Mean values of discomfort index under three roofing materials during the day

Roofing material	Black globe humidity index				
	0800 h	1000 h	1200 h	1400 h	1600 h
Aluminium	74.0h (0.9)	78.2g (1.1)	80.8e (1.4)	82.0d (1.2)	81.2e (1.4)
Asbestos	74.4h (0.9)	78.7f (1.1)	82.9c (1.4)	84.7a (1.6)	83.5b (1.8)
Zinc	74.2h (1.1)	79.2f (1.2)	83.0c (1.6)	84.9a (1.7)	83.9b (1.8)

a,b,c, = Values within column with the same letters are not significantly different ($p < 0.05$) based on DMRT.

Values in the brackets indicate standard deviation

Studies by Kelly and Bond (1958) on the effectiveness of various roofing materials in altering the radiant heat, showed that the radiant heat load produced under aluminium roof was as much as 536 w/m^2 (1.00 effectiveness), while asbestos and zinc were slightly less effective than aluminium at 0.96 and 0.98 respectively (*Table 7*).

Table 7. Shade effectiveness of new and 1-year-old roofing materials

Roof ing material	New	1-year-old
Aluminium	1.00 (standard)	0.99
Asbestos	0.96	0.94
Zinc	0.98	0.97

Source : Kelly and Bond (1958)

Effects on layer performance

Results on the production performance showed no significant difference between layers reared under aluminium, asbestos and zinc roofs (*Table 8*). However, there was a trend of increasing egg production and egg weight for layers reared under aluminium roof as compared with those reared under asbestos and zinc roof.

Among the three roofing treatments, the feed conversion efficiency (FCE) of layers reared under aluminium was the best

Table 6. Intensity of radiant heat load under three roofing materials during the day over a 35-week laying period

Roofing material	Radiant heat load (w/m^2) at chicken level				
	0800 h	1000 h	1200 h	1400 h	1600 h
Aluminium	452h	479g	502d	504d	498e
Asbestos	453h	483f	518b	530a	513c
Zinc	453h	487f	519b	536a	516c

a,b,c, = Values within column with the same letters are not significantly different ($p < 0.05$) based on DMRT

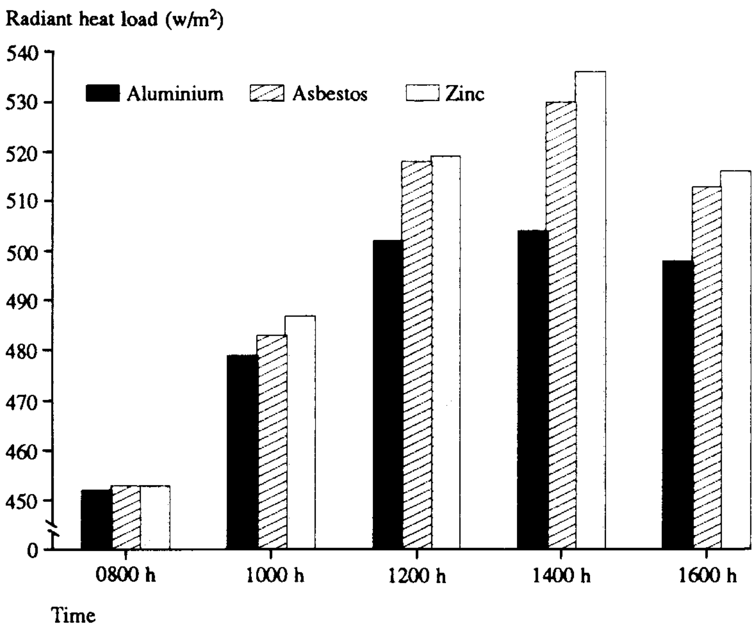

Figure 1. Radiant heat load under three roofing materials

Table 8. Effects of three roofing materials on the performance of layers

Roofing material	Egg prod. (%)	Egg weight (g/egg)	Weekly feed intake (g/bird)	Feed conv. efficiency
Aluminium	82.4a (3.0)	58.81a (1.1)	757.47a (7.3)	2.24b (0.1)
Asbestos	80.6a (4.1)	58.42a (1.0)	760.84a (16.4)	2.32a (0.1)
Zinc	81.1a (3.0)	58.62a (1.2)	748.89b (7.0)	2.25b (0.1)

a, b = Values within column with the same letters are not significantlydifferent ($p < 0.05$) based on DMRT.
Values in the brackets indicate standard deviation

(2.24), even though the feed intake recorded was higher than in the other two treatments. The higher feed consumption could be a result of lesser heat stress under aluminium roofing.

Conclusions

The effects of corrugated aluminium roofing sheets on discomfort index (BGHI) during the period of high solar radiation were significantly lesser than asbestos and zinc. Thus in a natural hot environment, aluminium roof provides more comfort with less heat stress than asbestos and zinc roofs.

As of laying performance, aluminium roofing had resulted in the best performance although not statistically significant. Perhaps, the reduction in heat stress under aluminium roofing has not reached a point that could significantly improve the production performance.

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