TECHNICAL NOTE

A comparison of halogen and incandescent infrared lamps for piglets

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Godbout, S., Guimont, H., Marquis, A. and De Foy, C. 2003. **A comparison of halogen and incandescent infrared lamps for piglets.** Canadian Biosystems Engineering/Le génie des biosystèmes au Canada **45**: 5.15-5.19. The purpose of this project was to compare the radiation and temperature distributions under incandescent and halogen lamps using two different lampshades. The main objectives were to establish the feasibility of replacing typical incandescent infrared piglet lamps with new halogen lamps. Temperatures due to radiation and the required electrical energy were measured. The halogen lamps produced a more uniform floor temperature distribution than the incandescent lamps. The floor temperature under the incandescent lamps decreased more rapidly as a function of the radial distance from the middle (directly under the lamp) than under the halogen lamps. At a 300 mm radius, these differences were (average of three heights and two power setting) 12 and 4.5˚C for the incandescent and halogen lamps, respectively. Thus, the incandescent lamps tended to concentrate the heat directly under the lamp producing stronger horizontal temperature stratification; however, the energy requirements of the two lamps were similar. Furthermore, the floor temperatures directly under the lamp with the halogen lamps varied from 30.3 to 34.5˚C for lamp heights ranging from 600 to 450 mm. For the incandescent lamps, these values were 36.5 and 42.7˚C for the same heights. Finally, the results show that it is possible to use halogen lamps instead of incandescent lamps. However, economic and life time studies were not carried out. **Keywords:** pigs, heat lamp, infrared radiation, pig nursery.

Le but de ce projet était de comparer la distribution de la radiation et de la température sous des lampes incandescentes et halogènes en utilisant deux types différents de déflecteurs. L'objectif principal était d'évaluer la possibilité de remplacer l'actuelle lampe incandescente à infrarouge utilisée dans les maternités par une nouvelle lampe halogène. La température due à la radiation et l'énergie électrique consommée ont été mesurées. Les lampes halogènes étudiées permettent une distribution de température plus uniforme qu'avec la lampe incandescente. La température sous la lampe incandescente décroît plus rapidement avec le rayon au sol qu'avec la lampe halogène. Sur un rayon de 300 mm, ces gradients (moyenne de trois hauteurs et de deux intensités) sont de 12 et 4,5ºC pour les lampes incandescentes et halogènes respectivement. Donc, la lampe incandescente tend à concentrer la chaleur directement sous le bulbe amenant une forte stratification horizontale de la température près du plancher. Cependant, les consommations d'énergie étaient similaire. La température radiante du plancher obtenue avec la lampe halogène varie de 30,3 à 34,5ºC pour des hauteurs de lampe variant entre 600 et 450 mm. Pour la lampe incandescente, ces valeurs sont de 36,5 et 42,7ºC pour une même variation de hauteur. Finalement, les résultats permettent de conclure qu'il est possible d'utiliser une lampe halogène à la place d'une lampe incandescente. Toutefois, aucune analyse économique et de vie utile ne fut réalisée. **Mots-clés**: porc, lampe chauffante, radiation infrarouge, maternité.

INTRODUCTION

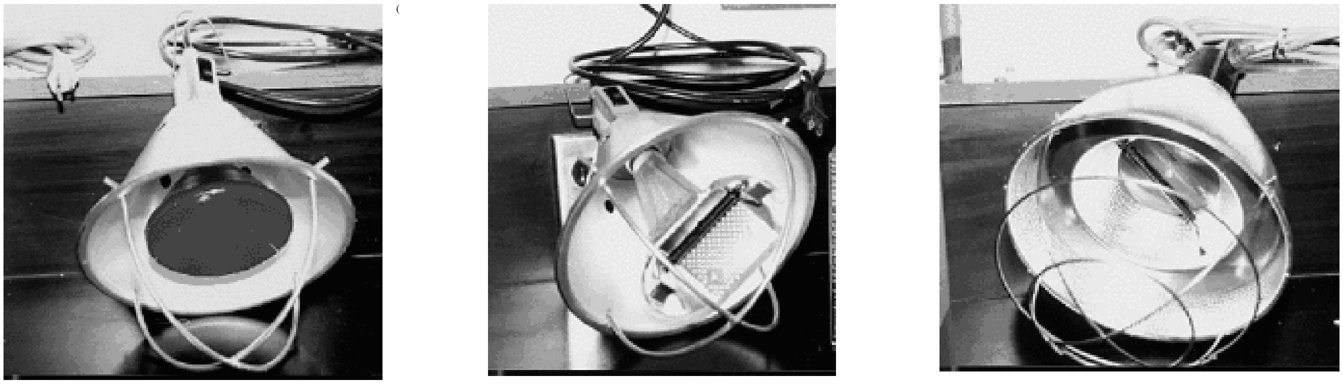
According to Guivarch (2002), the critical temperature for new born piglets is approximately 30˚C. At the end of the nursery period this temperature ranges from 22 to 24˚C. To keep a low room temperature for reduced heating costs, it is necessary to have a comfort zone in each pen. This zone is created by a supplementary heating system. The use of infrared lamps in farrowing and nursery units is widespread. Infrared rays pass through the air and heat only the objects they strike. Thus the heat of infrared rays keeps a piglet warm even though the temperature of the surrounding air is low. These lamps provide an adequate comfort zone without heating the entire building (Choinière et al. 1996), thus reducing heating costs (MacDonald 2000). Among different types of infrared lamps, incandescent lamps with a metal lampshade are often used.

In an attempt to improve piglets' heating system performance, some companies in Québec sell 175 W halogen infrared lamps with an adapter to fit a halogen lamp base into a standard shade. According to the manufacturer, these lamps have a longer life and a higher resistance to water and shock than incandescent lamps.

Guivarch (2002) concluded that halogen lamps give more uniform radiation than incandescent lamps. Furthermore, the halogen kits (halogen lamp fitting into a standard lampshade) give a radiation pattern between that of the halogen and the incandescent (PAR)lamps. He recommended that behaviour tests be carried out in farrowing and nursery units.

Since infrared lamps are a little more expensive, it would be of interest to have a better characterization of the performances of the various lamps. Thus, based on previous information, the objectives of this research were:

1. To characterize the radiation uniformity for the various lamps;
2. To evaluate radiation and temperature distributions for the halogen (kit) and incandescent lamps using a conventional lampshade;



(a) (b) (c)

Fig. 1. Lamps and lampshades tested: (a) incandescent lamp; (b) halogen lamp with conventional lampshade (HC); and (c) halogen lamp with new lampshade (HN).

3. To evaluate radiation and temperature distributions for the halogen lamp using a lampshade specially developed for the halogen lamp;
4. To measure the energy requirements of the various lamps.

MATERIALS and METHODS

Lamps

In pig housing, incandescent infrared lamps are commonly used. Indeed, the Philips 175 W (www.lighting.philips.com) infrared lamp takes a large part of the market. This lamp has the same shape as a conventional round and red incandescent lamp. According to the manufacturer, the lamp is comparable to a 250 W lamp and has similar heat output. Its estimated life is 5000 hours. This type of lamp uses a stainless steel lampshade (Canarm type, model HL; CSA with "Low" and "High" power setting) widely use in conventional buildings (Fig. 1).

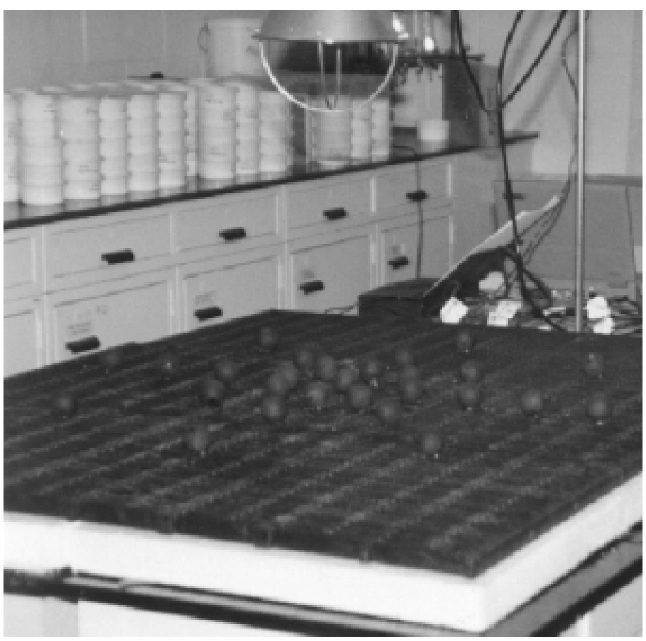


Fig. 2. Laboratory set-up.

The Ryu-ARM (Chungnam, Korea) infrared lamp (model HB-01, S/n 19905, CSA, standard lamp J 118 mm) is a heat lamp designed to absorb maximum visible rays and radiate infrared rays in mid and short wave lengths. According to the manufacturer, it has an average life of 10 000 hours. The same manufacturer provides a new lampshade type specially adapted to halogen infrared lamps. However, the manufacturer also offers an adapter to fix the halogen infrared lamp in the lampshade currently used with the incandescent lamp.

Set up

The tests were conducted at Laval University's laboratory. Thermocouples were centred inside ping-pong balls (40 mm diameter) painted black to measure the radiant temperature (Pereira et al. 1967). These sensors were placed on typical plastic piglet floor having a surface of 1.335 by 1.060 m (Fig. 2). Thirty temperatures were monitored, 27 inside the black ping-pong balls (radiant temperatures, see Fig. 3) , two directly on the plastic floor to validate the measurements, and one to measure the air temperature. The air temperature sensor was at least 3 m from the experimental set-up.

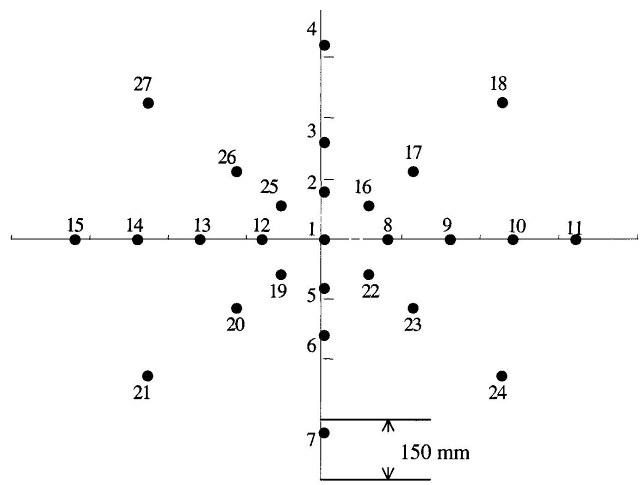


Fig. 3. Ping-pong ball positions.

Table 1. Statistical model.

Variation source	Degrees of freedom
Replications	2
Height	2
Bulbs	2
Power level	1
Residual error	46
Total	53

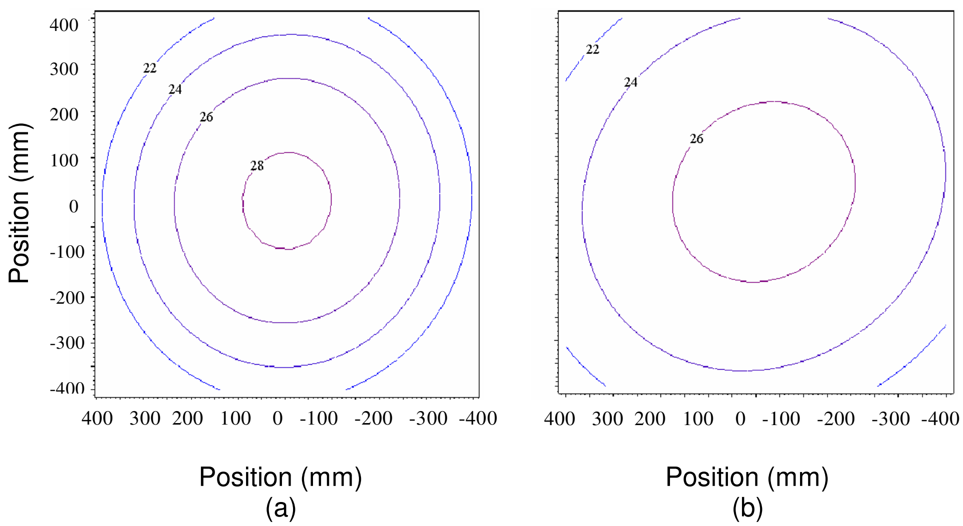


Fig. 4. Surface radiant temperature (°C) at 600 mm distance from the bulb with conventional lampshade at low power setting: (a) incandescent; (b) halogen.

A data acquisition system recorded the 30 temperatures. The power used by the lamps was recorded by a powermeter (Clip-on AC Power Meter, Yokagawa 2433, ValueTronics, Elgin, IL).

METHODOLOGY

This experiment included three different lamp heights (450, 530, and 600 mm from the lamp to the floor surface), two power settings (high and low) and two lampshades for the halogen lamps. Furthermore, to eliminate the effects of manufacturing defects, each test was carried out with three different lamps. A total of 54 tests were carried out (Table 1).

A pre-test established the steady state time period at 50 minutes. Thereafter, each test lasted approximately 60 minutes (the last 10 minutes were used to record data) in order to obtain thermal stabilization.

For each test, the power, amperage, and voltage were recorded. The measured and calculated (Eq. 1) powers were compared.

$$Power = V \times I \times PF \quad (1)$$

where:
Power = calculated power (W),
V = voltage (V),
I = amperage (A), and
PF = power factor.

The power factor (PF) was assumed to be one.

RESULTS

Temperature distribution

For each test, the ping-pong ball temperatures were recorded and compiled as a function of lamp and ball positions. This compilation allowed a detailed analysis and a graphical representation of the results. Two typical sets of results are shown in Fig. 4.

The tests demonstrated that the temperature patterns were different and were a function of the lamp type. In fact, the incandescent and halogen radiation patterns were circular and elliptical, respectively, as shown in Fig. 4.

Radial ground temperatures The ground temperatures under the halogen lamps were more uniform than those under the incandescent lamps. Table 2 shows the different temperature differences from the centre to two different radii. These differences reached a maximum of 16.7˚C for an incandescent lamp, but only 8.3˚C for a halogen lamp.

Furthermore, the ground temperatures under the halogen lamps were, for the heights tested, nearer to the temperature recommended for piglets than the temperatures under incandescent lamps (Table 3).

The lamp-ground height effects The data show that the floor temperatures (from 32.2 to 42.7˚C) directly under the incandescent lamp were greater than the recommended temperatures (from 22 to 30˚C) for the three heights and the two power settings tested. At high power setting (three averages), the ground temperatures directly under the lamp were 30.8, 31.3 and 39.5˚C, respectively for the halogen with new lampshade, halogen with conventional lampshade, and incandescent lamp. At low power setting, these temperatures were 5.5 and 2.5˚C lower for the incandescent and halogen lamps, respectively.

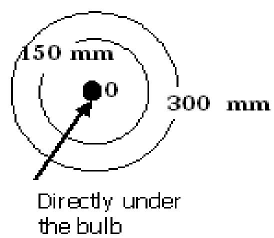
Table 2. Temperature difference (°C) from the centre to a radius of 300 mm.

Lamp types	Height of bulb (mm)			
	450		600	
	High power	Low power	High power	Low power
Incandescent	16.7	12.1	12.0	8.2
Halogen and conventional	7.7	3.9	3.8	2.9
Halogen and new	8.3	4.7	1.7	2.8

Table 3. Ground radiant temperatures (°C) at various distances from the centre and for various distances from the floor (adapted from Godbout and Guimont 2000).

Lamp types and intensity levels	Lamp distance from the lamp to the floor (mm)								
	450			530			600		
	Radial ground positions (mm)								
	0	150	300	0	150	300	0	150	300
ICH	42.7	30.2	26.0	39.3	30.0	24.5	36.5	29.1	24.5
ICL	36.1	27.3	24.0	33.6	26.8	23.5	32.2	26.9	24.0
HCH	34.5	30.5	26.8	32.4	29.6	26.8	30.3	28.5	26.5
HCL	30.4	28.7	26.5	29.2	26.3	24.9	27.8	26.3	24.9
HNH	33.4	28.7	25.1	30.3	38.5	26.0	28.7	28.5	27.0
HNL	28.7	26.6	24.0	28.1	26.3	24.7	27.3	25.5	24.5

ICH, ICL: Incandescent Philips lamp at high and low intensity levels
HCH, HCL: Halogen lamp with conventional lampshade at high and low intensity levels
HNH, HNL: Halogen lamp with new lampshade at high and low intensity levels



For the incandescent lamps at the high power setting, the floor temperature directly under the lamps dropped from 42.7 to 36.5˚C when the lamp height increased from 450 to 600 mm. At the low power level, these values were 36.1 and 32.2˚C.

For the halogen lamp at high power setting with a new lampshade, the floor temperature directly under the lamp dropped from 33.4 to 28.7˚C when the lamp height increased from 450 to 600 mm. For the conventional lampshade, these values were 34.5 and 30.3˚C, respectively.

For the halogen lamp at low power setting with new lampshade, the central floor temperature dropped from 28.7 to 27.3˚C when the lamp height increased from 450 to 600 mm. For the conventional lampshade, these values were 30.4 and 27.8˚C, respectively (see Table 3).

Table 4. Voltage, current, and power values for different lamps and intensities (adapted from Godbout and Guimont 2000).

Lamp and intensity level	Voltage (V)	Current (A)	Measured power (W)	Calculated power* (W=VA)
ICL (Philips low)	120.3	0.92	101.0	110.7
HNL	119.6	0.93	102.6	111.2
HCL	120.2	0.95	104.4	114.2
ICH (Philips high)	119.7	1.44	172.8	172.4
HNH	119.0	1.47	174.1	174.9
HCH	119.8	1.49	178.9	178.5

* Power factor assumed = 1.0
ICH, ICL: Incandescent Philips lamp at high and low intensity levels
HCH, HCL: Halogen lamp with conventional lampshade at high and low intensity levels
HNH, HNL: Halogen lamp with new lampshade at high and low intensity levels

Energy requirement study

The results show that the two types of lamps have the same energy requirements. The power required was approximately 175 W at high intensity and approximately 100 W at low intensity. This represents a 40% reduction between the two power settings (Table 4). The halogen lamps were using more power than the incandescent lamps but the difference was not significant ($P > 0.01$).

At high power setting, the powers measured and calculated were similar. This was not the case for the trial under a low power setting. This difference was related to a power factor not equal to one (Eq. 1) (Private communication. R. Boily, Professor (deceased), Département des sols et de génie agroalimentaire, Université Laval, Québec, Québec). Differences between the measured and calculated powers were also related to the power factor.

CONCLUSIONS

The test results indicate that for the heights tested (450, 530, and 600 mm from the floor to the lamp) and the two power settings, the floor temperature pattern is more uniform under the two halogen lamps than under the incandescent lamp. At a 300 mm radius, the differences between the centre temperature (directly under the lamp) and the temperature at a radius of 300 mm are (average of three heights and two power settings) 12 and 4.5˚C for the incandescent and halogen lamps, respectively.

The incandescent lamp tends to concentrate the heat in the centre resulting in stronger horizontal temperature stratification. Furthermore, for the incandescent lamp, the floor temperature directly under the lamp is high (32.2 to 42.7˚C) compared to the comfort temperature generally recommended (from 24 to 30˚C). The temperature distribution pattern is not circular for the halogen lamp. This is due to the “tube shape” of the halogen lamp. In most cases, the curves generated during the analysis have oval shapes.

According to the results, the two types of lamp have the same energy requirement. The power required is approximately 175 W at high power and approximately 100 W at low power. This represents a 40 % energy reduction between the two power levels. Economic and life time studies were not carried out.

RECOMMENDATIONS

The following recommendations should be considered before recommending halogen lamps.

1. The distribution of piglets under the two types of lamps should be studied. According to the tests, piglets were more uniformly distributed under halogen lamps;
2. Resistance (shocks, washing, etc.) and longevity tests should be conducted to complete the economic analysis;
3. A complete analysis of the luminous spectrum should also be carried out to verify the wave length patterns generated.

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