POWER-SAVING PROCEDURES AND ANIMAL THERMAL COMFORT AT A GROWING/FINISHING SWINE PRODUCTION UNIT

USO RACIONAL DE ENERGIA ELÉTRICA E CONFORTO TÉRMICO EM INSTALAÇÕES PARA SUÍNOS EM CRESCIMENTO E TERMINAÇÃO

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ABSTRACT

Climate control systems are one alternative for minimizing losses due to high temperature and large thermal variations in swine production units. However, because of the possibility of increase the productions cost, the benefits of climate control systems should be assessed before they are implemented. This research aims to assess the efficiency of different swine growing and finishing facilities regarding the animal thermal comfort, and the use of electric energy. The treatments are the following: S1 – two old automatic started fans + constructively inappropriate, S2 – two new automatic started + constructively inappropriate fans, S3 – one old manual started fan + constructively inappropriate, S4 - no one acclimatization system + constructively appropriate. The variables used in comparing these constructions were dry-bulb temperature, relative humidity, enthalpy and the thermal control index (ITH), as well as the electric variables and electric energy efficiency indexes. The use of two new fans and a sprayer system, both automatically started, provided animals with better thermal comfort, than compared wit h old ones. The use of automatic climate control equipment improves thermal comfort conditions as well as the use of electric energy.

Keywords: Swine Production, Thermal Comfort, Energy Conservation and Rational Use.

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RESUMO

Sistemas climatização são uma alternativa para minimizar perdas devido à altas temperaturas e grandes variações térmicas em instalações para criação suínos adultos. Porém, em virtude da possibilidade de aumento do custo de produção, os benefícios destes sistemas devem ser avaliados antes de serem implantados. Esta investigação teve como objetivo avaliar a eficiência de diferentes instalações e sistemas de climatização para suínos em crescimento e terminação, do ponto de vista do conforto térmico e da utilização de energia elétrica. Os tratamentos são os seguintes: S1 - dois ventiladores antigos com acionamento automático + construção civil inadequada, S2 - dois ventiladores novos com acionamento automático + construção civil inadequada, S3 - um ventilador velho com acionamento manual + construção civil inadequada, S4 – ausência de sistema de climatização artificial + construção civil adequada. As variáveis utilizadas na comparação destas construções foram temperatura de bulbo seco, umidade relativa do ar, entalpia e do controle térmico índice (ITH), bem como variáveis elétricas e índices de eficiência energética dos tratamentos. A utilização dos dois novos ventiladores e sistema de nebulização, ambos acionados automaticamente, forneceu melhores condições de conforto térmico, em comparação com ventiladores antigos. A utilização de climatização com controle automático melhora nas condições de conforto para os animais, bem como a utilização de energia elétrica.

PALAVRAS-CHAVES: Suinocultura, Ambiência, Conservação de Energia, Racionalização de Energia Elétrica.

INTRODUCTION

Swine raised in tropical countries are usually exposed to temperature higher than that required for their thermal comfort. Structural modifications to the rooms and the use of acclimatization equipment help to adjust existing conditions to the needs of these animals. The use of automatic started climate control systems can help to improve the microclimate in the sheds as it allows the local climate conditions to determine when the equipment should be started.

Energy efficiency is an important part of swine production. In many cases, use of energy efficiency as a criterion in selection and design of housing and ventilation systems can enhance production and well being of pigs while also reducing costs (MACDONALD, 2002).

Few works have been made aiming the reduction of electrical consumption acclimatization systems for pigs, especially for the reduction of temperature. HAEUSSERMANN (2007) achieved a reduction in energy consumption by 25% using spraying system, as compared to ventilation system.

Automatic climate control at first can account for an increase in the cost of the end product. However, benefits can be obtained throughout the production process if this resource is used rationally.

An assessment of the efficiency of swine production units varying both with regards to type of construction and acclimatization, considering both power consumption and the thermal comfort of animals, is important to decide which climate control system would be the most feasible. Climate-control systems may be used in a rational manner, which allow equipment activation to be conditional on local climate conditions.

This research aims to assess the efficiency of different swine production units regarding through to animal thermal comfort and use of electric energy.

MATERIAL AND METHODS

The experiment was conducted at a commercial swine production unit in Boituva, SP, Brazil. Two replicates were performed in 2004. The replicates performed with the first and second lots lasted 37 days (February-March) and 24 days (September-October) respectively. Hybrid pigs of both sexes, both in the growing and finishing phases (Agroceres-PIC commercial lineages), were used for this experiment.

The treatments are the following (figure 1): S1 - two old automatic started fans + spraying systems + constructively inappropriate, S2 - two new automatic started + spraying systems + constructively inappropriate fans, S3 - one old manual started fan + constructively inappropriate, S4 - no one acclimatization system + constructively appropriate.

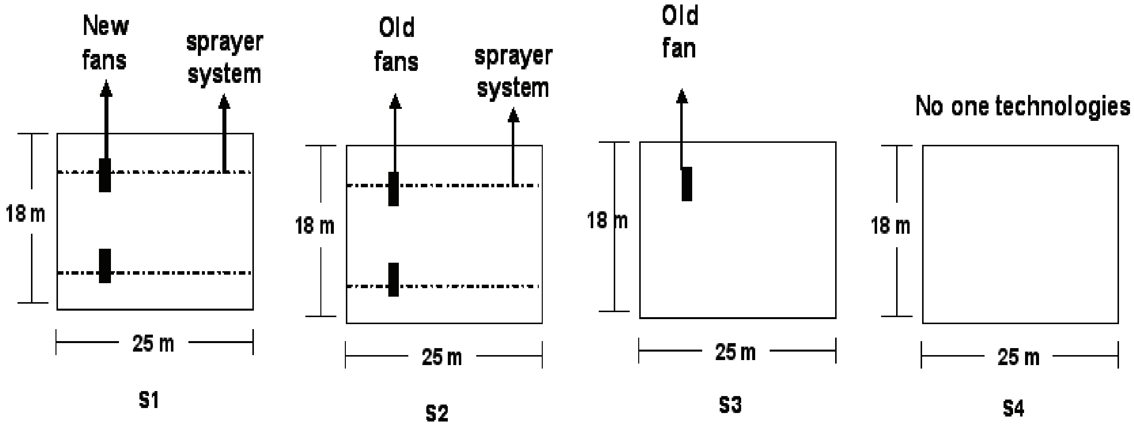

Figure 1. Layout of treatments

A building with a height from floor to ceiling of 2.40 m (7.87 ft), has an artificial climate control system and comprises an area roofed with asbestos cement sheets and an uncovered area with direct incidence of sunlight. This building, at which treatments S1, S2 and S3 were applied, was deemed as structurally inappropriate. A building with a height from floor to ceiling of 3.2 m (10.50 ft), and completely covered with clay roofing, is where treatment S4 was applied. This building was deemed as constructively appropriate.

Buildings were shared in rooms. Each treatment was allocated in a room.

Spraying and ventilation systems have been installed in all treatments of building A. Treatment S1 worked with two old automatic started fans, while treatment S2 worked with two brand new ones. Treatment S3 system consisted in just one old manual started fan. Treatment S4 has no one acclimatization system.

For the treatments under which the climate control equipment is automatically activated, the fans are turned on when temperature reaches 25º C (maximum comfort temperature for swine) and the sprayer system is activated when temperature reaches 27ºC. All the fans used had the same technical specifications.

A sensor was placed in each of the 4 treatments to measure both temperature and air humidity so Temperature-Humidity Indexes (ITH) (THOM, 1958), and the enthalpy values presented in each treatment, could be calculated. For the second period (replication), both the temperature and relative humidity values were recorded from the external environment. These variables were registered at every 15 minutes using computer equipment and programs for both data acquisition and accumulation. Climate and feed intake data were analyzed using an Analysis Variance. The other electrical variables were analyzed using Microsoft Excel program. Enthalpy (humid air energy per unit of dry air matter (kJ/kg of dry air)), was estimated using the equation used by PERISSINOTTO (2002):

$$H = 6{,}7 + 0{,}273 * Tbs + \{UR / 100 * 10 \wedge [(7{,}5 * Tbs) / (237{,}3 + Tbs)]\} \qquad \text{(Eq. 1)}$$

Where

H = enthalpy (kcal/kg of dry air)

t = dry-bulb temperature (oC)

UR = relative air humidity (%).

Linear regression analysis was used to correlating climate data from the internal environment of each treatment to that of the external environment.

The electrical variables (power demand, power consumption, and power factor) of the equipment were assessed using analyzers and multivariable energy meters installed in the circuit distribution boxes.

Specific consumption was used to estimate the amount of energy (kWh) to be consumed for producing per kilogram of meat produced. The load factor is one of the indicators of efficiency it shows how electric energy is used within a given period of time. The following equations were used to estimate these indicators:

a) Ces - Specific energy consumption for each treatment (acclimatization system)

$$Ces = \frac{CA_i}{QP_i} \qquad \text{(Eq.2)}$$

CAi = Electric energy consumption per lot (kWQh/lot)

QPi = Amount of product yielded in one lot by the consumption unit (treatment)

i = index refering to the swine raising lot, obtained through historic analysis of the data.

b) FCs - Load factor of the electric installation in the swine raising treatments

$$FCs = \frac{CA_i}{hDR_i} \qquad \text{(Eq. 3)}$$

Where:

CAi = Electric energy consumption per lot (kWh/lot) both at peak and off peak times,

i = index refering to the swine raising lot obtained by historic analysis of the data,

h = 730 hours – number of hours/ month (ANEEL – Brazilian Electricity Regulatory Agency),

DRi = Registered demand of maximum power for the swine raising lot.

These indexes are traditionally used in Brazil to electrical wire characterization (BUENO & ROSSI, 2006).

RESULTS AND DISCUSSION

This research work was conducted at a commercial swine production unit and individual animals weighing in the end of the experiment was not allowed to the researchers. Thus, it was not possible to statistically compare the average performance of animals. However some authors found improvement in weight gain and feed gain ratio with the use of ventilation and spraying systems (SARTOR et al, 2003; CARVALHO et al, 2004).

Table 1 shows the averages between climate variables, ITH, and enthalpy values for the lots and treatments studied.

Table 1. Average climatic parameters values for treatments and for external conditions.

	Exter	S1		S2		S3		S4	
	L2	L1	L2	L1	L2	L1	L2	L1	L2
Dry-Bulb Temperature (°C)	$23,13^{a}$	27.03^{b}	27.42^{d}	26.35^{a}	$26,23^{b}$	27.16^{b}	$29,35^{e}$	26.45^{a}	$26,80^{c}$
Relative Air Humidity (%)	$67,38^{d}$	66.11^{ab}	$54,00^{b}$	66.93^{b}	$53,40^{b}$	65.74^{a}	$51,96^{a}$	71.37^{c}	$55,05^{c}$
ITH	$77,47^{a}$	81.84^{b}	80.77^{d}	81.25^{a}	$79,48^{b}$	$81,93^{b}$	$82,45^{e}$	$81,77^{b}$	$80,29^{c}$
Enthalpy (kJ/kg of dry air)	$63,98^{a}$	74.97^{b}	69.20^{d}	73.77^{a}	$66,92^{b}$	$75,14^{b}$	$75,89^{e}$	$75,00^{b}$	$68,42^{c}$

S1, S2, S3 e S4 = Treatments; L1, L2 = replication; $P < 0.05$; Extern = external environment

The treatment S2 produced the best climate environment for the two studied periods ($P < 0.05$). Treatment S3 yielded the worst results. For dry-bulb temperature, S2 accounted for the smallest averages, being statically equal to S4 in the first lot. The other treatments were statistically different ($P < 0.05$). The means of climate parameters were considered statistically different for all treatments when compared with external environment conditions. All the temperature averages, except that from the external environment, exceeded the required temperature of 25°C. Relative air humidity values were satisfactory for all treatments in lot 1, except for S4, which showed an average slightly higher than the required average (60 to 70 percent) (SILVA, 1999). For lot 2, all humidity averages rated below those required. This parameter was satisfactory in the external environment.

As well as the spraying experiment, conducted by CARVALHO (2004), the spraying and ventilation system was unable to ensure that average-Dry-Bulb Temperature had been contained by the thermal comfort of the animals range.

According to HAEUSSERMANN et al (2007), spraying system improved thermal environment conditions for pigs. The authors reached this conclusion assessing, among other variables, the ITH. This system reduced the period in which the installation environment kept in more critical situations, i.e., higher values of ITH.

MANNO (2006) concluded that high temperature affects negatively weight gain in growing swines. In the present research work, same statements can not be made, because the average performance was not statistically compared. However, it can be noticed that the mean temperatures of period 2 were close to animal critical comfort temperature (MANNO, 2006), and that the weight gain rates were lower during this period.

The periods 1 and 2 presented ITH average values within the danger zone (from 79 to 83) (SILVA, 2000), except for the external environment. Between treatment means, S2 also presented better enthalpy values for both lots. However, it did not reach the satisfactory average for the specie (between 60.44 and 68.61 kJ/kg of dry air (MOURA, 1999)) for the first lot. In the second lot, S2 and S4, and the external environment as well, presented averages within the recommended values.

For temperature and humidity, treatment S4 presented the highest correlation coefficient to the external environment. Treatment S3 presented the second highest correlation coefficient followed by S1. Treatment S2 presented the worst correlation coefficient. This result was expected since treatment S4 cannot rely on any acclimatization equipment. Therefore, the microclimate value must be closer to the macroclimate value in the treatments that rely on acclimatization systems. The height between ceiling and roof and the material used for roofing the unit have caused the internal environment to be similar to the external one. Although treatment S3 presented the worst result of all treatments regarding to thermal comfort, it showed the second best correlation it did not have an efficient acclimatization system as treatments S1 and S2 do. This may be interpreted it is more efficient than and the rest of the treatments. Treatment S2 showed the worst correlation with the external environment ($P < 0.05$).

The power consumption value for fans and sprayers as accumulated in the two lots of the experiment was used for comparing consumption values (kWh) between the treatments. Table 2 shows the consumption values obtained and the cost for starting the equipment.

Table 2. Total power consumption values (kWh) and the cost for starting the acclimatization equipment in the 2 lots studied.

		S1	S2	S3
Total of energy consumption (kWh) for lot 1 + lot 2 during the entire experimental period	Fans	580.04	558.76	200.41
	Sprayers	193.99	193.99	78.06
Total consumption (kWh) during the entire experimental period		773.96	752.67	278.47
Total consumption (R$) during the entire experimental period*		154.79	150.53	55.69

*Considering a cost of R$ 20,00 per kWh.
S1, S2, S3 e S4 = Treatments

The analysis of table 2 shows that treatment S3 had both the lowest power consumption value and equipment starting cost, but it also provided the worst thermal conditions. Power consumption was also low as expected, because in the treatment it has only one fan.

Treatment S2 (new fans) provided animals with the best thermal conditions and power consumption was lower than that of treatment S1 (old fans).

The power efficiency indexes are shown in table 3.

Table 3. Power efficiency indexes for the lots during the study periods.

	S1		S2		S3	
	L1	**L2**	**L1**	**L2**	**L1**	**L2**
Specific consumption (kWh/kg)	.014	.011	.014	.007	.006	.002
Load factor	.391	.466	.392	.454	.243	.180
Density (animals/m^2)	.92	.91	.91	1.34	.90	1.20

S1, S2, S3 e S4 = Treatments, L1, L2 = replication

Specific consumption was lower (better) for S3, in the two lots. In lot 2, treatment S2 was tested with a higher density. An additional .35 animal per m2 was placed in the first lot. Treatment S2 had the conditions to produce more animals while consuming less power; this is why it had the second best result ($P < 0.05$).

As to the charge factor, treatment S1 was the best, followed by S2. So, treatment S1 presented the highest and therefore, best charge factor value (i.e. closer to the unit), which indicates that its electrical charges were more rationally used within the period of study.

CONCLUSIONS

The use of two new fans and an automatic spraying system enabled better thermal conditions inside the units while power consumption was also lower as compared to the values obtained for the old fans. It was not possible to draw any conclusions about the effect of the treatments on animal performance.

It was possible to get satisfactory performance results without a need for climate equipment, old or new, with manual or automatic driving, and without climate control equipment,in these study conditions.

Using spraying system conjugated with new automatic started fans improved thermal environment conditions in a building for swine production. Besides, using new fans reduce operational costs when compared with non-overhauled ones.

A well-managed and periodically maintained acclimatization system can minimize the effect of climate conditions on swine production units, thereby improving comfort conditions and reducing operation costs.

REFERENCES

BUENO, L.G.F., ROSSI, L.A., Comparação entre tecnologias de climatização para criação de frangos quanto a energia, ambiência e produtividade, Revista Brasileira de Engenharia Agrícola e Ambiental, 2006, v.10, n.2, p.497–504

CARVALHO, L.E. et al. Utilização da Nebulização e Ventilação Forçada sobre o Desempenho e a Temperatura da Pele de Suínos na Fase de Terminação. Revista Brasileira de Zootecnia, Viçosa, v.33, n.6, p.1486-1491, 2004.

FERREIRA, R.A. Efeitos do clima sobre a nutrição de suínos. 2001. In: Encontros Técnicos ABRAVES-SC, Concórdia. Memórias... Concórdia, SC: Embrapa Suínos e Aves, 2000. 95p.

HAEUSSERMANN A. et al. Cooling effects and evaporation characteristics of fogging systems in an experimental piggery. Biosystems Engineering, n. 97, 395 – 405. 2007.

MACDONALD, R. Saving Money by Maximizing Energy Use Efficiency in Swine Production. Advances in Pork Production. 2002. v. 13, p.99.

MOURA, D.J. Ventilação na suinocultura. In: SILVA I.J.O. Ambiência e qualidade na produção industrial de suínos. 1. ed. Piracicaba: FEALQ, 1999. 149 - 179.

PERISSINOTTO, M. Avaliação da eficiência produtiva e energética de sistemas de climatização em galpões tipo freestall para confinamento de gado leiteiro. 122f. Dissertação (Mestrado em Agronomia). ESALQ/USP, Piracicaba, 2002.

SARTOR, V. et al. Perfomance of an evaporative cooling system of a finishing phase swine barn, Scientia Agricola, Piracicaba, v. 60, n. 1, 2003.

SILVA I.J.O. Ambiência e qualidade na produção industrial de suínos. 1. ed. Piracicaba: FEALQ, 1999. 149 - 179.

SILVA, R.G. Introdução à Bioclimatologia Animal. São Paulo: Nobel, 2000. 286 p.

THOM, E.C. The discomfort index. Weatherwise. v.12, n.1, p.57-60, 1959.