EFFECT OF INDOOR AND FREE-RANGE RAISING SYSTEMS ON GROWTH PERFORMANCE OF MALE RHODE ISLAND RED CHICKENS†

[EFECTO DEL SISTEMA DE ALOJAMIENTO EN CAUTIVERIO O LIBERTAD EN EL COMPORTAMIENTO PRODUCTIVO DE POLLOS RHODE ISLAND RED]

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SUMMARY

Background. Rustic birds such as Rhode Island Red are adapted to the tropical environmental conditions. Raising them using free range in the tropics improve meat quality. However, the production cost is high when males are used for meat production, due to their low feed efficiency. **Objective.** To assess growth performance of Rhode Island Red male chickens as affected by indoor vs. outdoor housing systems between 7 to 14 weeks of age. **Methodology.** One hundred and twenty male chickens were allotted in two different housing systems: indoors vs. outdoor with acces to a free-range pasture of native plants. The experimental diet in growing stage (7-14 weeks of age) included processed *Mucuna pruriens* (soaked and cooked) in 15 % of the diet. For data analysis, a generilized linear model was used with repeated measures at different ages, considering effects of treatment, week and the interaction between both. The study of the whole experimental period considered the fixed effect of trial and liveweight at the start of the test as covariable. **Results.** Week was the most consistent effect, and treatment only affected feed intake, with values of 91.99 vs. 87.54 g/bird/day in indoor vs outdoor, respectively. There was only interaction between treatment and week in weight gain. For the whole period, there were no differences due to the housing systems for the variables under study. Nevertheless, initial live weight affected weight gain and conversion. **Implication.** Alternative raising systems for rustic birds in the tropics can be an option for small and middle producers, where animal welfare and feed costs improve. **Conclusion**. The productive behavior in Rhode Island Red male chickens is not modified by the raising system.
Key words: poultry; captivity and outdoors; processed mucuna.

RESUMEN

Antecedentes. Las aves rústicas como Rhode Island Red se adaptan a las condiciones ambientales que existen en el trópico. Se ha demostrado que mejora la calidad de la carne si se crían en sistemas al aire libre. Sin embargo, debido a su baja eficiencia alimenticia, se eleva su costo de producción por concepto de alimentación para la producción de carne. **Objetivo.** Evaluar el comportamiento productivo de pollos Rhode Island Red en dos sistemas de alojamiento entre las semanas 7 y 14 de edad. **Metodología.** Para ello se utilizaron 120 pollos machos que se distribuyeron en dos tratamientos: crianza en cautiverio o en libertad con pastoreo en vegetación nativa. La dieta experimental que se empleó en la etapa de crecimiento (7-14 semanas de edad), incluyó *Mucuna pruriens* procesada (remojo y cocción), al 15 % en la ración. Para el análisis de los datos se empleó un modelo lineal general, con medidas repetidas en el tiempo en la misma jaula, que consideró los efectos del tratamiento, la semana y la interacción de ambos. El estudio de todo el período experimental contempló el efecto fijo del tratamiento y el peso vivo, al inicio del experimento, como covariable. **Resultados.** El efecto de semana fue el más consistente y el tratamiento solo afectó el consumo de alimento, con valores de 91.99 y 87.54 g/ave/día para cautiverio y libertad, respectivamente. Solo hubo interacción significativa

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entre tratamiento y semana, para la variable ganancia de peso. Para la etapa completa, no hubo diferencias entre tratamientos para los indicadores en estudio. Sin embargo, se observó que el peso vivo inicial afecta la ganancia de peso y la conversión. **Implicación.** Los sistemas de alojamiento alternativos para aves rústicas en el trópico, constituyen una opción para pequeños y medianos productores, donde se mejora el bienestar animal y los costos por concepto de alimentación. **Conclusión.** El comportamiento productivo de los pollos Rhode Island red no se modifica por el sistema de crianza.
Palabras clave: aves; crianza en confinamiento y al aire libre; mucuna tratada.

INTRODUCTION

Recently, animal welfare has been an issue among numerous international organizations. On the other hand, the search for healthier foods has turned stronger, first in Europe and then in other countries (Jin *et al.*, 2019). These two facts have led to the proposal of free-range raising systems in poultry production, in which birds might express behaviors, typical of their species, diminishing stress due to high density, and also improving meat quality (Tong *et al*., 2014). Although some research studies have documented free-range raising in laying hens (Abou-Elezz *et al*., 2011, Abou-Elezz *et al.*, 2012), little has been reported on the behavior of meat-type chickens and broilers in the tropical area. Sogunle *et al.* (2013) proposed the use of dual-purpose birds when applying these raising systems in which hens can be used for egg production and males for meat.

Rustic birds such as Rhode Island Red chickens are characterized by their easier adaptation to tropical weather conditions. Therefore, they could be used in alternative poultry raising systems. Faustin Evaris *et al.* (2021) studied meat quality in this line raised in outdoor systems under tropical conditions and observed low fat and high protein content. For this reason these authors suggested raising them using free range in the tropics. However, one of the drawbacks of these systems is the high production cost by way of feeding (Baas-Osorio *et al*., 2019); thus, it is necessary to search for alternative and locally available feeds to improve this state of affairs. Therefore, the objective of this research was to assess growth performance of Rhode Island Red male chickens as affected by indoor vs. outdoor housing systems between 7 and 14 weeks of age.

MATERIALS AND METHODS

This study was carried out at Faculty of Veterinary Medicine and Animal Science of the Universidad Autonoma de Yucatan in Merida, Mexico during October to January.

Animals and management

One hundred and twenty male Rhode Island Red chickens (42 day-old), were used from seven to fourteen weeks of age. They were allocated in ten indoor floor pen replicates (2 m^2) having an initial live weight of 599.63 ±14.88 g, using bedding of wood shavings and including 12 birds per replicate. The birds of the first five cages remained in captivity which was considered as the control and those of the other five replicates had access to free-range pasture during the daytime (08:00 – 17:00 h). Each replicate of the outdoor group was provided with 24 m^2 of pasture area, having native plants, typical of sub-humid warm weather (AW0) in Yucatan, Mexico. All birds were vaccinated against Newcastle, Avian Pox and Gumboro diseases.

Housing systems and experimental diet

The experimental treatments consisted of raising birds indoors vs. indoor with access to free-range pasture of native plants. Both groups fed on a growing diet formulated according to allowances established by NRC (1994) for growers of laying brown egg breeds. The diet included processed *Mucuna pruriens* at 150 g/kg (table 1). Feed and water were provided *ad-libitum* in round feeders and automatic plastic drinking troughs, respectively.

Processing and preparation *Mucuna pruriens* seed meal

Seeds of mucuna, variety known as “ceniza”, were soaked in water for 24 h in plastic buckets (1:10; w/v); then, were cooked at 100°C for 60 min and dried in oven at 60°C for 72 h, according to the methodology proposed by Nwaoguikpe *et al.* (2011). Finally, they were ground in mill to obtain 3-mm particle size, and were stored in plastic bags.

Growth performance variables

Individual liveweights of birds were measured weekly, and feed intake was determined according to supplied and rejected feed on a per replicate basis. A technical scale (SARTORIUS, Germany) was used to weigh animals and feed. In accordance with these data, weight gain (weight at the end and the beginning of the week) and feed conversion were calculated as follows:

$$Conversion = \frac{Feed\ Intake}{Weight\ gain}$$

Table 1. Composing and calculated analysis of experimental diet.

Ingredients	Composition (%)
Maize meal	59.04
Soybean meal	22.04
Processed mucuna seed	15.00
Soybean oil	1.05
Dicalcium phosphate	0.86
Calcium carbonate	1.50
Sodium chloride	0.28
Anti-coccidial compound	0.05
Mycotoxin adsorbent	0.10
Pre-mixture of vitamins[1]	0.03
Pre-mixture of minerals[2]	0.05
Total	100
Calculated analysis (%)	
CP	18.03
ME (kcal/kg)	3040.23
Crude fiber	2.03
Lysine	0.90
Methionine	0.35
Ca	0.83
P	0.35

[1] Content kg^{-1}: vitamin A, 8000 IU; vitamin D, 2500 IU; vitamin E, 8 IU; vitamin K, 2 mg; vitamin B12, 0.002 mg; riboflavin, 5.5 mg; Pantothenic acid, 13 mg; niacin, 36 mg; choline, 500 mg; folic acid, 0.5 mg; thiamine, 1 mg; pyridoxine, 2.2 mg; biotin, 0.05 mg.
[2] Content kg^{-1} of diet: Manganese, 65 mg; iodine, 1 mg; iron, 55 mg, copper, 6 mg; zinc, 55 mg; selenium, 0.3 mg.

Experimental design and statistical analyses

In order to assess growth performance of male Rhode Island Red chickens raised indoor vs. outdoor housing systems, two statistical analyses were performed, one for determining performance by different variables under study per week and the other one in a complete period basis, from 7 to 14 weeks. In both, the generalized linear model was used with the MIXED procedure of SAS (2013), version 9.3. In the former, the model included fixed effects of treatment (cage and free-range), seven weeks of age, and the interaction week x treatment, measuring repeatedly at different times in the same experimental unit. The latter included fixed effect of treatment and live weight at the start of the trial as linear, quadratic and cubic covariable, in which only the linear was significant. The test of Tukey-Kramer (Kramer, 1956) was used for means comparisons at $P<0.05$.

RESULTS AND DISCUSSION

Table 2 shows analysis of variance of growth performance of Rhode Island Red male chickens aged 7-14 weeks. Out of the tested effects, week was the most consistent because it showed significance for all response variables. Treatment affected feed intake only, whereas the interaction between both was significant for live weight.

Feed intake was higher in chickens raised in captivity compared to that of free-range birds (91.99 vs 87.54 g/bird/day, respectively). This response could be apparent because birds raised in free-range systems have access to forages, insects, seeds and stones as sources of nutrients, hence, interfere with the normal intake of commercial feed. Li *et al.* (2017) reported similar result in similar chickens in a free-range raising.

Table 3 shows effect of age (week), regardless of housing systems, on growth performance of Rhode Island Red males between 7 and 14 weeks of age. Liveweight increased with time and, thus, weight gain showed ascending values, which were lower in the first two weeks under research and higher at 14 weeks of age. This was directly linked to feed intake because conversion proved more stable. This response was expected since chickens were in growing stage, the period when there is quantitative liveweight rise per unit of time (Safari *et al*., 2021).

The interaction between treatment and week was only significant for weight gain (Figure 1). The free-range treatment had a more homogeneous performance, as compared to that of the birds in captivity. In both, the greatest value was reached at 14 weeks of age; however between 7 and 8 weeks was higher for free-range chickens.

Table 2. Results of analysis of variance in productive performance parameters of growing Rhode Island Red males.

Sources of variation (Effects)	Freedom degrees	Live weight (g)	Weight gain (g/bird/week)	Feed intake (g/bird/day)	Feed conversion ratio (Feed:gain)
Treatment	1	(P=0.3960)	(P=0.9112)	(P=0.0334)	(P=0.1493)
Week	6	(P<0.0001)	(P<0.0001)	(P<0.0001)	(P=0.0018)
Trials*week	6	(P=0.2487)	(P=0.0145)	(P=0.2581)	(P=0.2833)

Table 3. Effect of age week on growth performance of male Rhode Island Red chickens.

Week	Live weight (g)		Weight gain (g/bird/week)		Feed intake (g/bird/day)		Feed conversion ratio (feed:gain)	
	Mean	SEM±	Mean	SEM±	Mean	SEM±	Mean	SEM±
7	697.51^{g}		97.88^{c}		61.56^{e}		4.58^{ab}	
8	795.24^{f}		97.73^{c}		66.26^{e}		4.82^{ab}	
9	940.59^{e}		145.35^{b}		78.67^{d}		3.94^{b}	
10	1069.56^{d}	9.17	128.97^{b}	7.06	87.98^{cd}	2.30	4.84^{ab}	0.25
11	1209.34^{c}		139.77^{b}		94.25^{bc}		4.74^{ab}	
12	1342.26^{b}		132.92^{b}		100.40^{b}		5.58^{a}	
14	1573.76^{a}		231.92^{a}		139.28^{a}		4.25^{b}	

^{a,b,c,d,e,f,}Different letters between rows differ at P < 0.05 (Kramer, 1956); SEM standard error of means.

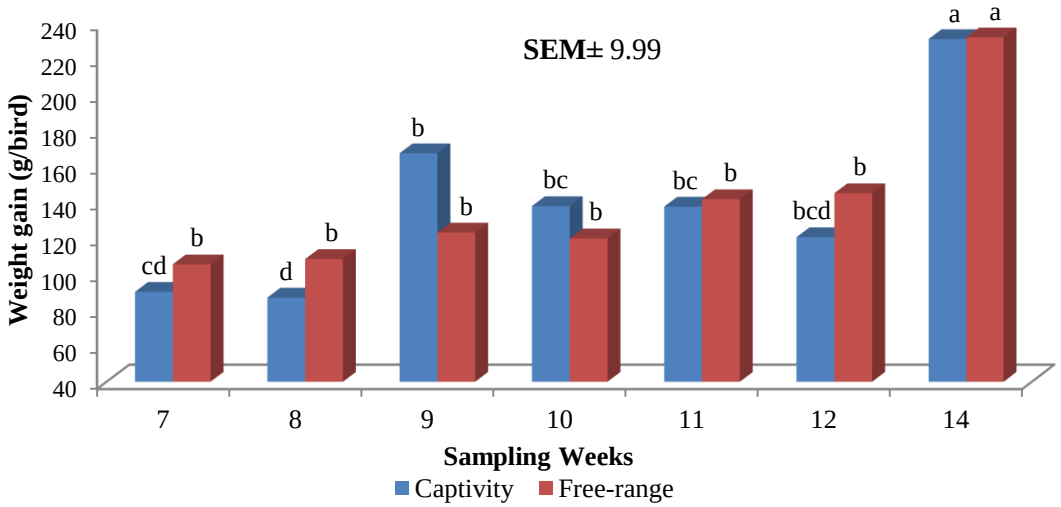

Figure 1. Interaction between treatment and week for weight gain in Rhode Island Red chickens. ^{a,b,c,d,}Different letters between columns differ at P<0.05 (Kramer, 1956)

According to Jin *et al.* (2019) and Sánchez-Casanova *et al.* (2020), in free-range systems, chicken growth is conditioned by different factors such as ambient temperature, size of provided outdoor area and housing density. In our study, birds in both treatments were confined in captivity at night, which could have mitigated the effect of temperature fluctuations.

Nonetheless, at daylight, in free-range chickens, the temperature was more variable, which was due to changes in light intensity, winds and other natural factors, providing better animal welfare. Additionally, studies made by Najafi *et al.* (2015) showed that lower housing density reduced physiological stress in birds, which probably occurred in the free-range treatment because they had a larger area to move around.

Table 4 shows productive performance in the complete growing stage for the parameters under study, in which there were no differences between indoor and free-range housing systems. Similar findings were obtained by Faustin Evaris *et al.* (2020) in Rhode Island Red chickens at 14 weeks of age by using a diet based on maize-soybean in a free-range system. According to Sosnówka-Czajka *et al.* (2017), the growth in birds under different raising systems depend on the genotype. Thus, the selection of rustic breeds, as the one in our research which is slow-growing, could be used under semi-intensive meat production system.

The analysis of covariance showed that initial live weight affects weight gain and conversion. A genetic correlation between these traits could justify the outcome. Taking into account this, further studies are demanded to describe growth performance in this breed at outdoor system with the use of alternative feeds such as *Mucuna pruriens.* Previous works such as Masoudi and Azarfar (2017) conducted a modeling research using some non-linear models to describe broiler growth parameters; they found high dependency between those models.

Table 4. Growth performance of Rhode Island Red males raised indoor vs. outdoor systems from 7-14 weeks of age.

Indicators	Trials		SEM±	P-value Trial	P-value Covariable
	Captivity	Free-range			
Live weight (g)	1577.78	1569.73	11.71	0.6471	0.2572
Weight gain (g/bird/week)	97.81	97.01	11.71	0.6471	0.0226
Feed intake (g/bird/day)	64.27	61.40	14.95	0.2240	0.6555
Feed conversion ratio (feed:gain)	4.60	4.43	0.06	0.1165	0.0142

The addition of processed mucuna at 15% in the diet of Rhode Island Red chickens in growing stage seems that did not affect productive behavior indicators in the two raising systems, considering the results of similar studies (Akure *et al.*, 2021). The physical processing of the seed and its inclusion level in the diet in the trial could have affected the outcome. In accordance with Sarmiento-Franco *et al.* (2019), water soaking and subsequent cooking of seeds of this legume reduce by 41% the concentration of L-DOPA, main anti-nutrient compound present in the seed, as well as other toxic metabolites. Therefore, it could be added to poultry diets without affecting productive behavior.

On the other hand, depending on the seed processing type, the inclusion level in animal diet could not affect intake, weight gain, and live weight (Mthana *et al*., 2022). Akure *et al.* (2021) did not report differences in productive behavior in fattening stage in broilers by including cooked seed at 20% in the ration with respect to a control without mucuna. According to them, with this inclusion level, there are enough digestible nutrients that may be used by the animal. However, parameters were deteriorated by including increased levels (30 to 40 %) in which residual effect of secondary metabolites could be evident and, hence, influenced negatively as the mucuna level was augmented in the diet.

The advantages of free-range poultry raising systems are numerous in tropical regions. Voluntary access to the outdoors not only improves wellbeing and comfort, but also benefits animal health. On the other hand, ethical aspects should be taken into account since male birds at one day of age coming from specialized laying breeds do not necessarily require to be sacrificed. By having different feed sources, feeding costs (Sarmiento-Franco and Sánchez-Casanova, 2019; Sarmiento-Franco *et al*., 2021) could be lower. Having the chance to include mucuna as an alternative in outdoor system also favors this latter aspect, which could in turn be beneficial to poultry producers at small and middle scale.

CONCLUSION

Productive performance in Rhode Island Red male chickens in growing stage was not modified by the raising systems under study.

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Compliance with ethical standards. Mexican regulation NOM-061-ZOO-1999 on feeding animals was applied

Data availability. Data are available with Madeleidy Martínez-Pérez (madeleidymartinez@gmail.com) upon reasonable request**.**

Author contribution statement (CRediT)
M. Martínez-Pérez - Investigation, Methodology, Writing – original draft. **L. Sarmiento-Franco -** Conceptualization, Funding acquisition, Writing – review & editing. **R. H. Santos-Ricalde -** Conceptualization, Funding acquisition. **C.A. Sandoval-Castro –** Resources and conceptualization. **A. M. Safwat -** Investigation and conceptualization. **Y. García Hernández -** Formal Analysis

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