Colegio de Postgraduados

Productive response of two genotypes of chickens (Mexican Creole and Sasso), in confinement and grazing white clover (*Trifolium repens* L.)

Hernández-Blancas, Berenice[1]; González-Cerón, Fernando[2*]; Pro-Martínez, Arturo[1]; Mendoza-Pedroza, Sergio Iban[1]; Gallegos-Sánchez, Jaime[1]

[1] Colegio de Postgraduados Campus Montecillo, Programa en Recursos Genéticos y Productividad-Ganadería, Carretera Federal México-Texcoco Km. 36.5, Montecillo Texcoco, Estado de México, México. C. P. 56264.

[2] Universidad Autónoma Chapingo Departamento de Zootecnia. Carretera Federal México-Texcoco Km 38.5, Texcoco, Estado de México, México. C. P. 56264.

* Correspondence: fgceron@colpos.mx

Citation: Hernández-Blancas, B., González-Cerón, F., Pro-Martínez, A., Mendoza-Pedroza, S. I., & Gallegos-Sánchez, J. (2024). Productive response of two genotypes of chickens (Mexican Creole and Sasso), in confinement and grazing white clover (*Trifolium repens* L.). *Agro Productividad*. https://doi.org/10.32854/agrop.v17i2.2846

Academic Editors: Jorge Cadena Iñiguez and Lucero del Mar Ruiz Posadas

Received: November 12, 2023.
Accepted: January 15, 2024.
Published on-line: April 04, 2024.

Agro Productividad, 17(2). February. 2024. pp: 183-190.

ABSTRACT

Objective: To determine the productive performance and forage consumption (*Trifolium repens* L.) of Mexican Creole and Sasso chickens, under two rearing systems (confinement or grazing).

Design/Methodology/Approach: One-hundred twenty-eight chickens (64 Mexican Creole (MC) and 64 Sasso (S)) of 35 d of age were randomly distributed in two production systems to obtain four repetitions (eight chickens per repetition) of each of the following genotype × system combinations: Mexican Creole in grazing, Mexican Creole in confinement, Sasso in grazing, and Sasso in confinement. A completely randomized experimental design with a 2×2 factorial arrangement was used, with genotype and production system as its main factors. The following variables were evaluated: feed consumption, weight gain, and feed conversion. Additionally, forage consumption in grazing birds was determined.

Results: The productive performance variables were not affected by the production system factors or by its interaction with the bird genotype. However, the genotype did influence the variables considered: the Sasso birds recorded better values ($p \leq 0.05$) than Mexican Creole specimens. Regarding forage consumption, no differences were observed ($p \leq 0.05$) between bird genotypes and, in both cases, the accumulated consumption at the 49 d of study was close to 60 g of DM.

Study Limitations/Implications: It is necessary to carry out a socioeconomic study as well as a defoliation level analysis with the aim of improving the use of the resource.

Findings/Conclusions: Mexican Creole birds had a lower productive performance with a similar forage consumption.

Keywords: Mexican Creole, Sasso, productive performance, forage consumption, *Trifolium repens* L.

INTRODUCTION

In recent years, consumers have become increasingly interested in poultry products from non-intensive systems (Moyle *et al.*, 2014) that include slow-growing broilers (Sossidou *et al.*, 2011), such as the Mexican Creole and Sasso chickens. While the Sasso chicken is

generated by a global company specializing in poultry genetics (Sasso, 2022), the Mexican native chicken is a product of the natural selection of the birds brought by the Spanish conquistadors (Cuca-García, 2018). This genotype is found in rural communities, where they complement their diet with grains, insects, and even forage (Terrell, 2013). The last element is relevant for poultry meat production in alternative grazing systems (Lorenz *et al.*, 2013). Stadig *et al.* (2016) determined that confined Sasso chickens had a higher weight, but they did not find any differences in feed consumption and feed conversion between birds raised in grazing or confinement systems. Few studies have sought to determine the amount of forage consumed by chickens in grazing production systems. Mugnai *et al.* (2014) reported a consumption of 59 g of DM d^{-1}, while Dal Bosco *et al.* (2014) recorded a consumption range of 14 to 55 g of DM d^{-1} in naked neck chickens. The commercial exploitation and utilization of Mexico's poultry genetic resources requires evidence that supports their productive performance in face of the options available in the market for non-conventional production systems, such as Sasso chicken (Aman *et al.*, 2017). To date, no such information seems to exist in reference works.

MATERIALS AND METHODS

One hundred twenty-eight mixed chickens (64 Mexican Creole (MC) and 64 Sasso (S)) of 35 d of age were randomly distributed in two production systems (grazing or confinement), obtaining four repetitions (eight birds per repetition) of the following genotype × production system combinations: Mexican Creole in grazing, Mexican Creole in confinement, Sasso in grazing, and Sasso in confinement. While confined birds were kept in pens within a natural environment poultry house with movable side curtains, the birds in the grazing system had access to a white clover (*Trifolium repens* L.) meadow from 9:00 am to 5:00 pm and spent the rest of the day sheltered within the poultry house. A 5-cm layer of wood chip was laid inside 1.1×1.4 m pens (8 birds per pen, 5.2 birds m^2). Each pen had a 10 kg hopper feeder and a 5 L plastic poultry drinker. From 35 to 56 d of age, the chickens were fed a diet of 2,550 kcal of metabolizable energy per kg and 17% crude protein; subsequently and until they were 84 d old, they were offered commercial balanced feed (minimum CP, 17.5%; crude fat, 4%; minimum crude fiber, 4.5%; maximum ash, 5.5%; maximum humidity, 12%; NFE by difference, 55.5%). Food and water were offered *ad libitum*.

Productive performance

The following variables were recorded weekly with chickens from 35 to 84 d of age: feed consumption, weight gain, and feed conversion. Feed consumption was calculated according to the following equation:

$$\textit{weekly feed consumption}\ (\mathrm{g}) = \textit{food offered}\ (\mathrm{g}) - \textit{residual food}\ (\mathrm{g})$$

Weight gain was calculated as follows:

$$\textit{weekly weight gain}\ (\mathrm{g}) = \textit{weight at the end of the week}\ (\mathrm{g}) - \textit{weight at the beginning of the week}\ (\mathrm{g}).$$

Finally, feed conversion was calculated with the following formula:

$$\textit{feed conversion}\ (g)/(g) = \textit{feed consumption}\ (g)/\textit{weight gain}\ (g)$$

Additionally, variables were measured cumulatively for the study period (35 to 84 days of age).

Forage consumption determination

In each repetition, grazing MC and S birds had access to 42 m^2 (10.5×4 m) white clover meadows. Following the suggestions of Hasan *et al.* (2013) for slow-growing broilers, each bird had access to 5 m^2. In each repetition, the flock remained seven days within each plot. Subsequently, the group moved to an area that had been allowed to rest from grazing for 15 days. Each plot had a 5 L plastic poultry drinker and a 2 m^2 mobile shade. The consumption of white clover was determined using the methodology of Dal Bosco *et al.* (2014): a 0.75×0.75 m exclusion pen was set up in each repetition, to keep the chicken away from that area. In each 7 d period in which the meadow was occupied, a forage sample was taken randomly when the animals entered (GM_S, herbaceous mass present) and exited (GM_e, remaining forage after consumption), using a 0.75×0.75 m metal frame to measure the forage. In addition to the content in the exclusion pen (GM_u, undisturbed forage mass), the forage was cut 5 cm from the ground and subsequently placed in a paper bag to be weighed on a Metrology® BCH-5000 scale (Mexico) with a 5,000 g capacity and 0.5 g resolution. Once the weight of the forage sample had been obtained, the plant material was left to dry in the sun until a constant weight was reached, verified with the same scale. Finally, the GM_S, GM_e, and GM_u values were substituted in the equation proposed by Lantinga *et al.* (2004) to estimate forage consumption (FC):

$$FC = \left(GM_S - GM_e\right) + \left\{ \frac{\left[1 - \left(\frac{GM_e}{GM_S}\right)\right]}{-\ln\left[\frac{GM_e}{GM_S}\right]} \right\} \times \left(GM_u - GM_S\right)$$

Statistical analysis

The data of the studied variables were analyzed with the MIXED procedure of SAS version 9.3 (SAS, 2011), under a completely randomized experimental design with a 2×2 factorial arrangement, using genotype and production system as main factors. The effect of each factor was considered significant ($p \leq 0.05$). The adjusted means were compared using the Tukey's test.

RESULTS AND DISCUSSION

Overall, the genotype × production system interaction was not significant ($p > 0.05$) with respect to feed consumption, except from 56 to 70 d of age, when the S birds had a higher consumption in both systems than the MC, which reduced their consumption under confinement (Table 1). These results match the findings of Ponte *et al.* (2008), who reported that birds with access to grazing consume more balanced feed. Likewise, throughout the study period, S birds consumed 20-70% more feed ($p \leq 0.05$) (Table 1). The average consumption of S birds reached 101 g bird^{-1} d^{-1}; this figure was higher than the 40-87 g bird^{-1} d^{-1} range reported in previous studies with this same genotype under grazing conditions (Yitbarek *et al.*, 2016; Bayesa *et al.*, 2020). Meanwhile, the average MC consumption was 70 g bird^{-1} d^{-1}: there results are higher than those reported by Segura-Correa *et al.* (2004) and Matus-Aragón *et al.* (2021). These authors recorded those Mexican Creole chickens consumed between 52 and 63 g bird^{-1} d^{-1}. Finally, feed consumption was impacted ($p<0.05$) by the production system up to 70 d of age (except from 56 to 63 d); higher results were obtained in the confinement system than in grazing. These were not the expected results. Unlike the results obtained by Ponte *et al.* (2008), the consumption of concentrated feed should have increased as a consequence of the greater energy demanded by grazing. This increase would have been caused by the grains and oils that are the main source of energy in poultry diets (Terrell, 2013).

Table 2 shows no overall effect of the genotype × production system interaction or the production system itself ($p>0.05$) on weight gain. In contrast, S birds gained more weight than MC birds ($p<0.05$), recording 1,731 and 852 g, respectively, from 35 to 84 d of age. The weight gain (34 g bird^{-1} d^{-1}) matches the 13 and 34 g bird^{-1} d^{-1} reported for S chicken up to 56 d of age by Yitbarek *et al.* (2016) and Sanka *et al.* (2020). Nevertheless, the MC birds gained 852 g in weight during the 49 d of the study, a value lower than the

Table 1. Adjusted means (±SE) of feed consumption† (g) of Sasso and Mexican Creole chickens reared in grazing or confinement.

Factor	Level	Age (d)							
		35-42	43-49	50-56	56-63	63-70	70-77	77-84	35-84
Genotype	Sasso	556 a	665 a	694 a	592 a	756 a	850 a	852 a	4965 a
	Mexican Creole	456 b	534 b	498 b	400 b	515 b	476 b	491 b	3497 b
	standard error	16	7	19	18	12	40	33	128
System	Confinement	533 a	614 a	629 a	492	601 a	650	683	4179
	Grazing	479 b	584 b	562 b	500	670 b	675	659	4283
	standard error	16	7	19	18	12	40	33	128
Genotype × System	Sasso × Grazing	535	657	675	541 ab	756 a	860	849	4873
	Mexican Creole × Grazing	578	674	713	459 b	584 b	490	517	3693
	Sasso × Confinement	488	555	546	642 a	757 a	840	855	5057
	Mexican Creole × Confinement	423	512	449	342 c	446 c	461	464	3301
	standard error	22	10	27	541 ab	756 a	57	47	182
P value									
Genotype		*	***	***	***	***	***	***	***
System		*	*	*	NS	*	NS	NS	NS
Genotype × System		NS	NS	NS	*	*	NS	NS	NS

a,b,c: Mean values per column with a different letter are statistically different ($p \leq 0.05$). *** ($p \leq 0.0001$), * ($p \leq 0.05$), NS=not significant ($p>0.05$). † Feed consumption is relative to the consumption of balanced feed.

Table 2. Adjusted means (±SE) of weight gain (g) of Sasso and Mexican Creole chickens reared in pasture or confinement.

Factor	Level	Age (d)							
		35-42	**43-49**	**50-56**	**56-63**	**63-70**	**70-77**	**77-84**	**35-84**
Genotype	Sasso	251 a	210 a	268 a	236 a	252 a	227 a	287 a	1731 a
	Mexican Creole	115 b	127 b	134 b	114 b	114 b	109 b	132 b	852 b
	standard error	5	6	11	16	9	17	132	41
System	Confinement	181	170	193	192	171	152	235	1293
	Grazing	185	167	209	159	196	183	184	1290
	standard error	5	6	11	16	9	17	132	41
Genotype × System	Sasso × Grazing	255	205	284	198	286 a	266	269	1763
	Mexican Creole × Grazing	115	130	134	119	105 c	101	100	818
	Sasso × Confinement	246	216	253	275	217 b	187	305	1698
	Mexican Creole × Confinement	116	124	134	109	124 c	116	165	887
	standard error	8	8	16	23	13	23	34	58
P value									
Genotype		***	***	***	*	***	*	*	***
System		NS	NS	NS	NS	NS	NS	NS	NS
Genotype × System		NS	NS	NS	NS	*	NS	NS	NS

a,b,c: Mean values per column with a different letter are statistically different ($p \leq 0.05$). *** ($p \leq 0.0001$) * ($p \leq 0.05$), NS=not significant ($p > 0.05$).

1,096 g reported by Matus-Aragón *et al.* (2021), while the daily weight gain at 49 d (17.4 g bird^{-1} d^{-1}) was close to the 14.5 g bird^{-1} d^{-1} reported by Segura-Correa *et al.* (2004).

In the case of feed conversion (Table 3), there were no differences ($p > 0.05$) between the genotype × production system interaction and the production system as an individual factor. However, the genotype of the bird was significant ($p < 0.05$): MC birds obtained a greater feed conversion than the S birds (1.0 to 1.6 g more food per each g of weight gain). S chickens had a conversion of 3.1 g g^{-1} at 49 d. This result is similar to the 2.8 to 2.9 g g^{-1} at 84 d of age reported by Rocha-Barros *et al.* (2009), but lower than the 2.7 to 3.4 g g^{-1} reported by Sanka *et al.* (2020). The conversion in Mexican Creole chickens was 4.2 g g^{-1} from 35 to 84 d of age. This value was higher than the 3.5-4.14 g g^{-1} range reported at 84 d by Matus-Aragón *et al.* (2021); however, at 49 d of age, the feed conversion reached 4.2 g g^{-1}, which is very similar to the 4.36 g g^{-1} found by Segura-Correa *et al.* (2004).

The productive performance of birds of zootechnical interest is determined by the genotype, age, environmental conditions, availability of nutrients, and the health status of the animals, among other factors (Lesson and Summers, 2001). The results obtained in the present research are related to the abovementioned factors, given the marked difference in weight gain and feed conversion between the genotypes of the birds under study. Sasso chickens recorded better values in both variables, as a result of the genetic selection process to which this commercial race has been subject to for many years (Aman *et al.*, 2017).

No differences in forage consumption were observed ($p \leq 0.05$) between the genotypes of the birds: in both cases, the animals consumed ≈60 g DM of forage in the 49 d of evaluation (Table 4). Few research have been carried out to quantify the forage consumption

Table 3. Adjusted means (±SE) of feed conversion [†] (g) of Sasso and Mexican Creole chickens reared in grazing or confinement.

Factor	Level	Age (d)							
		35-42	43-49	50-56	56-63	63-70	70-77	77-84	35-84
Genotype	Sasso	2.2 b	3.1 b	2.6 b	2.6 b	3.1 b	4.0	3.2	2.9
	Mexican Creole	3.8 a	4.2 a	3.8 a	3.6 a	4.7 a	4.0	4.6	4.2
	standard error	0.2	0.1	0.1	0.2	0.2	0.4	0.6	0.2
System	Confinement	3.3	3.8	3.5 a	2.9	3.6	4.5	3.1	3.4
	pasture	3	3.6	2.9 b	3.3	4.2	3.6	4.7	3.7
	standard error	0.2	0.1	0.1	0.2	0.2	0.4	0.6	0.2
Genotype × System	Sasso × Grazing	2.1	3.2	2.4	2.8	2.6 a	3.2	3.5	2.8
	Mexican Creole × Grazing	3.7	4	3.4	3.9	5.7 c	4.0	5.9	4.6
	Sasso × Confinement	2.3	3.1	2.8	2.4	3.6 b	4.8	2.9	3.0
	Mexican Creole × Confinement	4.2	4.5	4.2	3.3	3.6 c	4.1	3.2	3.7
	standard error	0.2	0.2	0.2	0.0	0.3	0.5	0.8	0.3
P value									
Genotype		***	***	***	*	*	NS	NS	NS
System		NS	NS	*	NS	NS	NS	NS	NS
Genotype × System		NS	NS	NS	NS	*	NS	NS	NS

a,b,c: Mean values per column with a different letter are statistically different (p≤0.05). SE=standard error, *** (p≤0.0001), * (p≤0.05), NS=not significant (p>0.05). [†] Feed consumption is relative to the consumption of balanced feed.

of grazing birds; after a literature review, no studies were found about this variable for Sasso or Mexican Native chickens. However, when the present results are compared with the findings of Dal Bosco *et al.* (2014), naked neck chickens had a higher consumption (14 and 55 g DM bird^{-1} d^{-1}) than MC and S chickens (1.143 and 1.218 g DM bird^{-1} d^{-1}, respectively). Ponte *et al.* (2008) report that hybrid chickens (RedBro CouNu × RedBro M) consume 3.0 to 6.5 g of DM bird^{-1} d^{-1} of forage, while Rivera-Ferre *et al.* (2007) recorded an average consumption of 10.7 g of DM bird^{-1} d^{-1} among ISA-957 birds. The amount of forage consumed by birds of both genotypes in the present study was lower than the results of Dal Bosco *et al.* (2014) and Mirabito and Lubac (2001). Several factors limit forage consumption, including genotype, sex, age, and grazing schedule (Almeida *et al.*, 2012).

Table 4. Adjusted means (±SE) of forage consumption by Sasso and Mexican Creole chickens with access to grazing.

Level	Age (d)							
	35-42	43-49	50-56	56-63	63-70	70-77	77-84	35-84
Sasso	3.2	3.2	9.1	4.3	12.3	6.7	17.2	56.0
Mexican Creole	1.9	1.9	3.9	7.9	15.8	8.4	19.9	59.7
standard error	0.5	0.5	1.5	2.6	4.7	1.5	4.2	8.1
P value	NS	NS	NS	NS	NS	NS	NS	NS

a,b,c: Mean values per column with a different letter are statistically different (p≤0.05). *** (p≤0.0001), * (p≤0.05), NS=not significant (p>0.05).

Furthermore, due to their digestive physiology, chickens prefer less fibrous ingredients (Martens *et al.*, 2012). Eyles (1963) reported that forage can represent up to 5% of the daily DM consumption of free grazing poultry. Likewise, not all types of birds make an optimal use of forage (Singh and Cowieson, 2013).

CONCLUSIONS

Regardless of their genotype, Mexican Creole and Sasso chickens tend to have similar productive performance, whether they are raised in confinement or grazing. Meanwhile, Sasso birds showed better weight gain and feed conversion values from 35 to 84 d of age than Mexican Creole chickens. Both genotypes of grazing chickens consume similar amounts of white clover: ≈60 g of DM in 49 days, *i.e.*, 1.143 and 1.218 g of DM bird^{-1} d^{-1}.

REFERENCES

Almeida GFD, Hinrichsen LK, Horsted K, Thamsborg SM, Hermansen JE. (2012). Feed intake and activity level of two broiler genotypes foraging different types of vegetation in the finishing period. *Poultry Science* 91, 2105–2113. doi:10.3382/ps.2012-02187

Aman, G., Bekele, B., Bereket, D., Gebriel, A., Tadesse, A., Edget, J. 2017. Production performance of Sasso (distributed by ethio-chicken private poultry farms) and Bovans brown chickens breed under village production system in three agro-ecologies of Southern Nations, Nationalities, and Peoples Regional State (SNNPR), Ethiopia. *International Journal of Livestock 8*(157). 145 – 157.

Bayesa, T., Ahmad, S., Wasihun, H., Mohamed, A. 2020. Effect of Age and Genetic Groups on Growth Performance of Crossed Koekoek and Sasso Chickens. *Biochemistry and Molecular Biology 5*(4). 44 – 49. Doi: 10.11648/j.bmb.20200504.11

Cuca-García, J. (2018). La avicultura de traspatio en México: Historia y caracterización. *Agro Productividad, 8*(4). 30–36. https://revista-agroproductividad.org/index.php/agroproductividad/article/view/669

Dal Bosco, A., Mugnai, C., Rosati, A., Paoletti, A., Caporali, S., Castellini, C. 2014. Effect of range enrichment on performance, behavior, and forage intake of free-range chickens, *Journal of Applied Poultry 23*(2). 137–145. Doi:10.3382/japr.2013-00814.

Eyles, D.E., 1963. Non-Ruminants. In: A.N. Worden, K.C. Sellers & D.E. Truibe (Eds), Animal Health, Production and Pasture. Longmans, London, pp. 359–383.

Hasan, E., Arda, Y., Nurel, D., Ahmet, S., Mustafa, D. 2013. Comparison of meat quality and fatty acid profile in slow-growing chicken genotypes feddiets supplemented with *Origanum vulgare* or *Melissa officinalis* leaves under the organic system. *British Poultry Science 56*(4). 477– 485. Doi: 10.4081/ijas.2013.e64

Lantinga, A., Neuteboom, J., Mei, J. 2004. Sward methods in Herbage Intake Handbook, 2nd ed. P.D. Penning, ed. The British Grassland Society, Reading, UK 2.23–52

Lesson, S. and Summers, J. 2001. Nutrition of the chicken, 4°edition. University of Guelph, Guelph, Ontario, Canada NIG ZW1, Department of animal & poultry science.

Lorenz, C., Kany, T. , Grashorn, M. 2013. Method to estimate feed intake from pasture in broilers and laying hens. *Archiv für Geflügelkunde. 77*(3). 160–165.

Martens S.T., Tassilo B., Jerome M., Lascano C. (2012). Alternative plant protein sources for pigs and chickens in the tropics - Nutritional value and constraints: A review. *Journal of Agriculture and Rural Development in the Tropics and Subtropics*. 113. 101-123. 2012.

Matus-Aragón, M., González-Cerón, F., Salinas-Ruiz, J., Sosa-Montes, E., Pro-Martínez, A., Hernández-Mendo, O., Cuca-García, J., Chan-Díaz, D. 2021. Productive performance of Mexican Creole chickens from hatching to 12 weeks of age fed diets with different concentrations of metabolizable energy and crude protein. *Animal bioscience 34*(11). 1794 – 1801 Doi: 10.5713/ab.20.0682

Mirabito, L., Lubac, L. 2001. Descriptive study of outdoor run occupation by “Red Label” type chickens. *British Poultry Science* 42. S16–S17.

Moyle, J.R., Arsi, K., Woo-Ming, A., Arambel, H., Fanatico, A., Blore, P.J., Clark, F.D., Donoghue, D.J., Donoghue, A.M. 2014. Growth performance of fast-growing broilers reared under different types of production systems with outdoor access: Implications for organic and alternative production systems, *Journal of Applied Poultry Research 23*(2). 212–220. Doi: 10.3382/japr.2013-00882.

Mugnai, C., Sossidou, E.N., Dal Bosco, A., Ruggeri, S., Mattioli, S., Castellini, C. 2014. The effects of husbandry system on the forage intake and egg nutritive characteristics of laying hens. *Journal of the Science of Food and Agriculture 94*(3). 459–467. Doi:10.1002/jsfa.6269.

Ponte, P., Rosado, C., Crespo, J., Crespo, D., Mourão, J., Chaveiro, M., Brás, J., Mendes, I., Gama, L., Prates, J., Ferreira, L., Fontes, C. 2008. Pasture Intake Improves the Performance and Meat Sensory Attributes of Free-Range Broilers, *Poultry Science 87*(1). 71–79 Doi:10.3382/ps.2007-00147

Rivera-Ferre, M.G., Lantinga, E.A., Kwakkel, R.P. 2007. Herbage intake and use of outdoor area by organic broilers: effects of vegetation type and shelter addition. *Journal or Animal Science 54*(3). 279–291 Doi:10.1016/S1573-5214(07)80020-0

Rocha-Barros, D.L., Sakomura, N.K., Cardoso, D., Dorigam, J.C., Marcato, S., Kochenborger, B. 2009. Crescimento e desempenho de linhagens de aves pescoço peladocriadas em sistema semi-confinado. *Ciências agrotecnologia, 33*(3). 875–881. Doi:10.1590/S1413-70542009000300030

Sanka, Y.D., Mbaga, S.H., Mutayoba, S.K. 2020. Evaluation of growth performance of Sasso and Kuroiler chickens fed three diets at varying levels of supplementation under semi-intensive system of production in Tanzania. *Tropical Animal Health and Production* 52. 3315 – 3322 Doi:10.1007/s11250-020-02363-x

SAS Institute Inc. 2011. SAS user's guide: statistics version. SAS Institute Inc., Cary, NC, USA. 959 pp.

Sasso, 2022. Guía de manejo para pollos de engorda. Hendrix Genetics.

Segura-Correa, J.C., Sarmiento-Franco, L., Magaña-Monforte, J.G., Santos-Ricalde, R. 2004 Productive performance of Creole chickens and their crosses raised under semi-intensive management conditions in Yucatan, Mexico, *British Poultry Science 45*(3). 342–345. DOI: 10.1080/00071660410001730833

Singh y Cowieson.2013.Range use and pasture consumption in free-range poultry production. *Animal Production Science 53*(11):1202-1208. DOI:10.1071/an13199

Sossidou, E., Dal Bosco, A., Elson, H., Fontes, C. 2011. Pasture-based systems for poultry production: Implications and perspectives. *World's Poultry Science Journal 67*(1). 47–58 Doi:10.1017/S0043933911000043.

Stadig, L.M., Rodenburg, T.B., Bert J.A., Barbara, D., Frank, A.M. 2016. Effects of free-range access on production parameters and meat quality, composition and taste in slow-growing broiler chickens. *Poultry Science 95*(12). 2971–2978. Doi:10.3382/ps/pew226.

Terrell, S. 2013. Pastured Poultry Nutrition and Forages. National sustainable agriculture information service. USA https://www.sare.org/wp-content/uploads/Pastured-Poultry-Nutrition-and-Forages.pdf (Recuperado: mayo 2022).

Yitbarek, M.B., Mersso, B.T., Wosen, A.M. 2016. Effect of dried blood-rumen content mixture (DBRMN) on feed intake, body weight gain, feed conversion ratio and mortality rate of SASSO C44 broiler chicks. *Journal of Livestock Science* 7. 139–149. DOI:10.13140/RG.2.1.4295.1286