Economic viability in free-range chicken production

Dian Lourençoni, Amelia Carvalho Faustino, Sílvia Helena Nogueira Turco, Otoniel Cajuí Bonfim, Luana Carolina Rocha E Silva L C, Ana Carolina De Sá Silva Lins.

AGRICULTURAL AND ENVIRONMENTAL ENGINEERING, Universidade Federal do Vale do São Francisco, Rua Antonio Carlos Magalhães, 510, Country Club, JUAZEIRO, 48902-300, Brazil.
dian.lourenconi@univasf.edu.br

Corresponding author: Dian Lourençoni, Email: dian.lourenconi@univasf.edu.br

© The Author(s) 2021. Published by Oxford University Press on behalf of the American Society of Animal Science.

This is an Open Access article distributed under the terms of the Creative Commons Attribution License (http://creativecommons.org/licenses/by/4.0/), which permits unrestricted reuse, distribution, and reproduction in any medium, provided the original work is properly cited.
Abstract: Despite the lack of large-scale farming of free-range chickens in Brazil, their production generates income in the countryside and prevents exodus of rural families in agricultural regions. The objective of this study is to evaluate the economic viability of free-range broiler production in different facilities. The experiment was conducted in two different sheds (masonry shed-SM and wooden shed-SW) located in the Plural Space of the Universidade Federal do Vale São Francisco, municipality of Juazeiro, BA. Here, 200 heavy red French free-range chickens were distributed in the two sheds and were raised from the 1st to the 88th day (slaughter). Assuming that the minimum age for slaughter is 85 days, the results indicated that at least 205 birds in SM and 217 birds in SW were necessary for the producer to earn the minimum per capita monthly wage in Brazil (2020); at least 411 birds in CG and 600 birds in GM were found to be necessary to achieve maximum productivity at the end of the production cycle. The maximum profitability in the slaughter of the chickens was achieved at an age of 60 days.

Key words: alternative poultry production, free-range chicken, poultry production, productive performance.
| Abbreviation | Description                                      |
|-------------|--------------------------------------------------|
| AEB         | average energy expense per bird                  |
| AFB         | average feeding expense per bird                 |
| AFC         | amount of feed consumed                          |
| ALB         | average labor expense per bird                   |
| AMB         | average medication expense per bird              |
| APB         | average purchase expense of a chick              |
| ASB         | average sales value per bird                     |
| Cw          | current weight                                   |
| Cwl         | weight obtained in the last measurement          |
| FC          | feed conversion                                  |
| FI          | feed intake                                      |
| MO          | mortality                                        |
| NBH         | number of birds housed                           |
| NDB         | number of dead birds                             |
| SM          | sheds masonry                                    |
| SW          | sheds wooden                                     |
| VB          | viability                                        |
| WG          | weight gain                                      |
**Introduction**

The poultry production of free-range chicken meat is a segment of alternative poultry farming with a great potential for growth in the Brazilian market. The high demand can be traced back to the growth of consumers who are concerned about the environment, animal welfare, and their health. (Madeira et al., 2010; Del Castilho et al., 2013; Albino et al., 2014).

The caipira semi-intensive rearing system provides the birds free access to a grazing area, where they do not graze for significant calories, but they do eat insects and likely some grains and legumes allowing them to express their natural behavior. Additionally, consumption of proportional amounts of chicken feed, vegetation, and crops by the birds guarantees differences in the meat quality when compared to intensively reared birds (Savino et al, 2007; Fanático et al., 2007; Mikulski et al., 2011).

To make poultry rearing profitable, it is essential to be aware of the main parameters affecting their meat quality (Cruz et al., 2017), particularly in regions experiencing high temperatures. However, Cordeiro et al. (2014) inferred that it is essential to select strains that are adapted and resistant to heat stress for greater meat production efficiency at lower costs.

Although the production of free-range chickens is not practiced at large-scales in Brazil, this system generates income for small and medium farmers because they have more productivity and lower investments (Yakubu & Ugbo, 2011; Almeida et al., 2013); it also reduces exodus of rural families in agricultural regions. Therefore, this study aims to evaluate the economic viability of production of free-range chickens raised in different facilities.
Materials and Methods

The experiment was conducted between June and September 2018, in two sheds for free-range chickens, one masonry (SM), and the other wooden (SW), located in the Plural Space of the Universidade Federal do Vale São Francisco, municipality of JuazeiroBA, (9°26'58.7") south latitude and (40°31'30.6") west longitude, in the Submédio São Francisco region. According to the Koppen's climate classification, the climate of the region is considered to be semi-arid. The average air temperature in GA was 31.4 ºC and in GM was 30.8ºC and relative humidity in GA was 37.2% and GM 39.1%. The study was approved by the Ethics Committee on Animal Use of UNIVASF (number 0005/260218).

The sheds were 3 m wide, 6 m long, and 2.80 m high. They had 0.50 m high walls, 0.10 m of maravalha bedding, and blue polyethylene curtains. The SM was covered with a ceramic roof, concrete floor, facades protected by masonry bricks, and sides with galvanized wire screens. The SW was covered with coconut straw, concrete floor, facades made from eucalyptus stakes, and sides with galvanized wire screens. There was no mechanical ventilation system in the sheds, and both had a 200-m² picket area with tifton grass, providing an area of 2 m² bird⁻¹.

In both facilities, 100 chickens of the French red Pesadão strain were randomly distributed, regardless of sex, in the sheds, and each housed at a density of 5.6 chickens m⁻². The experiment was initiated when the broilers were one day old. Vaccinations and medication were carried out with the help of a veterinarian who accompanied the whole experiment.

The commercial feed used was formulated to meet the energy and protein requirements for maintenance and growth. The feed was adjusted according to the rearing phase as follows: the initial feed was given from 1 to 30 days, and the feed for growth from 31 to 90 days. The
basic composition of the feed was ground whole corn, calcitic limestone, soybean meal, meat and bone meal, and a mixture of minerals, vitamins, and amino acids, with the complementation of fruits, vegetables, and tifton grass.

During the first 15 days, the chicks were kept warm using 250-W infrared lamps at night and the curtains were kept partially closed. Water was distributed ad libitum throughout the rearing period, and the feed was fixed as summarized in Table 1. After 30 days of age, the birds had access to the outdoor area (picket) with tifton grass.

For each shed, the performance of the free-range chickens was evaluated according to the results of their weight gain (WG, g), feed intake (FI, g), feed conversion (FC, g g⁻¹), mortality (MO, quantity), and viability (VB, %). The indices were evaluated weekly until the fourth week and fortnightly from the fourth week until the end of the experimental period. Equations 1 to 5 were used to obtain the production indices as follows:

\[ \text{WG} = \text{Cw} - \text{Cwl} \]  
\[ \text{FI} = \text{AFC} / \text{NBH} \]  
\[ \text{FC} = \text{FI} / \text{WG} \]  
\[ \text{MO} = (\text{NDB} / \text{NBH}) \times 100 \]  
\[ \text{VB} = (\text{NBH}_\text{current} / \text{NBH}_\text{start}) \times 100, \]  

where \( \text{WG} = \) weight gain (g); \( \text{Cw} = \) current weight (g); \( \text{Cwl} = \) weight obtained in the last measurement; \( \text{FI} = \) feed intake (g); \( \text{AFC} = \) amount of feed consumed (g); \( \text{NBH} = \) number of birds housed (quantity); \( \text{FC} = \) feed conversion (g g⁻¹); \( \text{MO} = \) mortality (%); \( \text{NDB} = \) number of dead birds (quantity); \( \text{VB} = \) viability (%); \( \text{NBH}_\text{current} = \) number of birds in the week (quantity), and \( \text{NBH}_\text{start} = \) number of birds housed at the beginning of the experiment (quantity).
The profitability per bird was calculated as expressed in Equation 6:

\[
APB = ASB - (AFB + ALB + APB + AEB + AMB)
\]  

(6)

where APB = average profitability per bird (R\$ bird\(^{-1}\)); ASB = average sales value per bird (R\$ bird\(^{-1}\)); AFB = average feeding expense per bird (R\$ bird\(^{-1}\)); ALB = average labor expense per bird (R\$ bird\(^{-1}\)); APB = average purchase expense of a chick (R\$ bird\(^{-1}\)), AEB = average energy expense per bird (R\$ bird\(^{-1}\)), and AMB = average medication expense per bird (R\$ bird\(^{-1}\)).

Lastly, simulations were performed to quantify the minimum number of birds required for a producer to realize a monthly income according to the per capita minimum wage (R\$998.00).

Results and discussion

The production indices obtained from both the sheds are summarized in Table 2. At day 90 we observed an average FC of 3.9 g g\(^{-1}\) and 4.0 g g\(^{-1}\), and cumulative FC of 12.82 kg and 13.42 kg for the SM and SW, respectively. In a study conducted by Dias et al. (2017), evaluation of the caipira strains—Pescoço Pelado, Vermelho Pesadão, Carijó, Master Griss, and Colorido—yielded an FC of 2.84, 2.94, 2.90, 3.00, and 2.88 g g\(^{-1}\) and an FI of 5.05, 5.14, 5.17, 5.17, and 5.22 kg, respectively. The results of our study were compared with those of Dias et al. (2017); the FC and FI medians in this study were found to be larger than those obtained in all the strains studied by Dias et al. (2017), with the FC ranging from 32.65 to 36.05\%, and the FI ranging from 149.41 to 161.08\%.

The most inefficient FC of the chickens was obtained in the final period of rearing owing to the loss of efficiency in converting FI to body weight (Santos et al., 2005).
occurs when the chickens are close to attaining their maximum growth rate. The slight difference in WG, FI, and FC between the two sheds possibly arises from the fact that SM provides better internal thermal conditions than SW (average air temperature in SM = 31.4 °C, average temperature in SW = 30.8 °C, relative air humidity in SM = 37.2%, and relative air humidity in SW = 39.1%).

Mortality in the sheds was within the acceptable limits for a number of weeks (Picoli, 2004; Lupantini, 2015); however, in the first week, mortality rates greater than 1% were observed in both sheds, which may indicate that the chicks received were of inferior quality (Ross, 2012). In the seventh week, there was an increase in the mortality rate in both sheds as a result of social behaviors; aggressive behavior of males on females was observed, which resulted in a higher mortality rate of females.

The mortality rate of the chicken directly affects the performance of the farm. Consequently, this variable is considered in the determination of the payment made to poultry farmers. Souza et al. (2012) and Lupantini (2015) stated that feed conversion, feed consumption, viability/mortality, and age during slaughter are the most important parameters when evaluating the zootechnical performance of broiler flocks.

Figure 1 shows all the variable production costs incurred during the experiment for both sheds. It can be observed that the main production cost is feed, which can reach 70% of the production cost, as observed by several authors (Mendes et al., 2004; Barbosa et al, 2007; Rufino et al., 2017), and the FC is one of the key factors influencing the production cost. The second largest cost is labor; notably, labor costs were calculated by considering that the producer earned a monthly income according to the current per capita minimum wage in Brazil (R$998.00); this value was divided between the two sheds, which initially had a total of 200 birds, to obtain the labor costs.

The Ministry of Agriculture and Supply (MAPA), through the NBR 16389/2015,
regulates the raising of free-range chickens in Brazil and approves the use of feeds exclusively originating from vegetable products, which leads to a reduction in feed costs. It also mentions that farming can be intensive until 28 days of age and extensive (with access to enclosures) after this period. It prescribes the minimum age for slaughter to be 85 days. Other authors propose that slaughter can be at approximately 77–90 days of age (Rosa et al., 2000; Mendes et al., 2001, Moreira 2012).

As shown in Figure 2, considering the sale of the live free-range chicken at R$12.00 kg\(^{-1}\) (2nd semester of 2018), we determined that the profitability of the poultry in this study reached its highest level at approximately 60 days of production, realizing profits of R$0.71 and R$0.62 bird\(^{-1}\) for the masonry and wood sheds, respectively.

It is observed that the producer needs to wait for the ideal age to slaughter the free-range chicken (MAPA, 2015). However, for both sheds, if the producer is responsible for managing the shed for 85 days, he/she will not be able to earn the minimum monthly salary (R$998.00).

With the production cost data already defined, simulations were performed to quantify the minimum number of birds required for a producer to realize a monthly income according to the per capita minimum wage (R$998.00). It was found that at least 205 birds in SM and 217 birds in SW (Figure 3A and B) were required to earn a minimum monthly income. The maximum profitability is obtained at approximately 60 days of production and it decreases to zero at the end of the cycle.

Continuing with the simulations, for the producer to achieve maximum profitability at the end of the production cycle, it was found that least 411 birds in SM and 600 birds in SW were necessary. This would accrue profits of R$7.40 and R$9.14 per bird in SM and SW, respectively, in addition to the per capita minimum monthly salary (Figure 4A and B).

If we put the same number of birds in both sheds (600 birds) during the simulations,
the producer will accrue profits of R$9.68 and R$9.14 per bird in SM and SW, respectively, apart from the minimum per capita monthly salary (Figure 5).

It is worth noting that the costs of land acquisition or rental, as well as the structure of the sheds was not considered in this study.

**Conclusion**

Considering a minimum slaughter age of 88 days, at least 205 birds in SM and 217 birds in SW are required for the producer to realize a monthly income according to the per capita minimum wage (R$998.00) and at least 411 birds in SM and 600 birds in SW to achieve maximum productivity at the end of the production cycle.

Because NBR 16389/2015 recommends a minimum slaughter age of 85 days, it is advisable to revise it such that small producers can slaughter chickens at their maximum profitability (60 days old), and consequently increase the number of the production cycles per year.
Acknowledgement

The authors would like to thank FACEPE, FAPESB, CAPES, and CNPq for supporting this research.

Conflict of interest statement

The authors declare no real or perceived conflicts of interest.
Literature Cited

Abreu, L. R. A., Boari, C. A., Pires, A. V., Pinheiro, S. R. F., Oliveira, R. G., Oliveira, K.M., Gonçalves, F. M., & Oliveira, F. R.. 2014. Influência do sexo e idade de abate sobre rendimento de carcaça e qualidade da carne de codornas de corte. Revista Brasileira de Saúde e Produção Animal, 15(1), 131-140. doi: https://doi.org/10.1590/S1519-99402014000100020

Albino, L.F.T. et al. Sistema Alternativo de Criação de Aves. Criação de Frango e Galinha Caipira. 4.ed. Viçosa: Aprenda Fácil, 2014. pp. 18-95

Almeida, E. C. J., Carneiro, P. L. S., Wenceslau, A. A., Farias Filho, R. T., & Malhado, C. H. M. 2013. Características de carcaça de galinha naturalizada Pelico comparada a linhagens de frango caipira. Pesquisa Agropecuária Brasileira, 48(11), 1517-1523. doi: https://doi.org/10.1590/S0100-204X2013001100013

Barbosa, J. F. V., Nascimento, M.P. S. B., Diniz, F. M., Nascimento, H. T. S., Neto, R. B. A. Sistema alternativo de criação de galinhas caipiras. Alimentação. Manejo nutricional. Embrapa Meio Norte. Sistemas de Produção 4. Novembro, 2007

Cruz, F L., Espósito, M., Barbetti, N B de S., Fassani, É J., Faria, P B. & Esteves, C. 2017. Qualidade da carne de aves da raça Rodhe Island red criadas em sistema alternativo. Ciência Animal Brasileira, 18, e37834. Epub August 21. doi: https://doi.org/10.1590/1089-6891v18e37834

Cordeiro, M.B., Freitas, H.J., Aquino, E.O., Sousa, E.M. 2014. Avaliação do estresse térmico em frangos caipiras criados em condições climáticas do Estado do Acre. Enciclopédia Biosfera, 10 (19) 358-365.

Del Castilho, C.C., Santos, T.T., Rodrigues, C.A.F. and Torres Filho, R.A. 2013. Efeitos do sexo e genótipo no desempenho e características de produção de frangos de corte ao ar...
Dias, A. N., Maciel, M. P., de Oliveira Aiura, A. L., Arouca, C. L. C., Silva, D. B., & de Moura, V. H. S. 2017. Linhagens de frangos caipiras criadas em sistema semi-intensivo em região de clima quente. Pesquisa Agropecuária Brasileira, 51(12), 2010-2017.

Lupatini F. Avaliação do efeito de variáveis produtivas na conversão alimentar de frangos de corte [thesis]. Goiânia (GO): Universidade Federal de Goiás; 2015.

Madeira, L A, Sartori, JR., Araujo, P C., Pizzolante, C Isolante., Salda ha, É S P B & Pezzato, A C. 2010. Avaliação do desempenho e do rendimento de carcaça de quatro linhagens de frangos de corte em dois sistemas de criação. Revista Brasileira de Zootecnia, 39(10), 2214-2221. doi; https://doi.org/10.1590/S1516-35982010001000017

MAPA- Ministério da Agricultura e Abastecimento. 2015. NBR 16389: Avicultura: produção, abate, processamento e identificação do frango caipira, colonial ou capoeira. Brasília, DF, 9p.

Mikulski, D. 2011. Growth characteristics of two strains of native broilers (White Naked Neck and Black Svrljig) fattened under a semi-intensive system. African Journal of Biotechnology, 10 (70): 5813-15818. doi: https://doi.org/10.5897 / AJB11.1153

Mendes AA, Nães IA, Macari M. Produção de frangos de corte. Campinas: FACTA; 2004. 356 p.

Moreira, A.S., Santos, M.S.V., Vieira, S. S., Tavares, F.B., and Manno, M.C.. 2012. Desempenho de frangos caipiras alimentados com rações contendo diferentes níveis de energia metabolizável. Arquivo Brasileiro de Medicina Veterinária e Zootecnia, 64(4), 1009-1016. https://doi.org/10.1590/S0102-09352012000400030

Picoli, K. P. Avaliação de sistemas de produção de frangos de corte no pasto. 2004. Dissertação (Titulo de Mestre) - Universidade Federal de Santa Catarina. Forianópolis, 2004.
Rufino, J. P. F. Cruz, F. G. G., Tanaka, E. S., Melo, R. D., and Feijó, J. C. 2017. Análise econômica da inclusão de farinha do resíduo de buriti na alimentação de poedeiras comerciais. Revista Ciência Agronômica, 48(4), 732-738. doi: https://dx.doi.org/10.5935/1806-6690.20170085

Santos, A.L., Sakomura, N.K., Freitas, E.R., Fortes, C.M. L. S., Carrilho, E. N, V. M., and Fernandes, J. B. K. 2005. Estudo do Crescimento, Desempenho, Rendimento de Carcaça e Qualidade de Carne de Três Linhagens de Frango de Corte. Rev. Bras. Zootec., 34:158 9-1598. doi: https://doi.org/10.1590/S1516-35982005000500020.

Savino, V. J. M. Coelho, A. A. D., Rosário, M. F., and Silva, M. A. N. 2007. Avaliação de materiais genéticos visando à produção de frango caipira em diferentes sistemas de alimentação. Revista Brasileira de Zootecnia, 36 (3): 578-583. doi https://doi.org/10.1590/S1516-35982007000300009

Souza, X.R., Faria, P.B., & Bressan, M.C.. 2012. Qualidade da carne de frangos caipiras abatidos em diferentes idades. Arquivo Brasileiro de Medicina Veterinária e Zootecnia, 64(2), 479-487. doi: https://doi.org/10.1590/S0102-09352012000200031

Veloso, R.C., Pires, A.V., Torres Filho, R.A., Pinheiro, S.R.F., WinKelstroter, L.K., Alcântara, D.C.,and Cruz, C.C.D.C.S.. 2014. Parâmetros de desempenho e carcaça de genótipos de frangos tipo caipira. Arquivo Brasileiro de Medicina Veterinária e Zootecnia, 66(4), 1251-1259. doi; https://doi.org/10.1590/1678-6312

Yakubu; Ugbo, S.B. 2011. An assessment of biodiversity in morphological traits of Muscovy ducks in Nigeria using discriminant analysis. International Conference on Biology, Environment and Chemistry, 1: 389-391.
Table 1. Amount of feed offered to the chickens during the experimental period.

| Phase, days                  | Quantity, g bird-day⁻¹ |
|------------------------------|------------------------|
| Pre-initial (1st to 10th)    | 40                     |
| Initial (11th to 30th)       | 80                     |
| Growth (31st to 60th)        | 100                    |
| Termination (61st to 90th)   | 120                    |
Table 2. Mean values of average weight gain (WG, g), cumulative feed intake (FI, g), cumulative feed conversion (FC, g g⁻¹), mortality (MO, %), and viability (VB, %) obtained experimentally.

| Gallery | Weekly | Average weight gain, g | Cumulative feed intake, g | Cumulative feed conversion, g g⁻¹ | Mortality, % | Viability, % |
|---------|--------|------------------------|--------------------------|----------------------------------|--------------|--------------|
| SM      | 1      | 0.039                  | 0.16                     | 4.2                              | 2.0          | 98.0         |
|         | 2      | 0.149                  | 0.45                     | 2.4                              | 0.0          | 98.0         |
|         | 3      | 0.204                  | 1.02                     | 2.6                              | 0.0          | 98.0         |
|         | 4      | 0.278                  | 1.59                     | 2.4                              | 0.0          | 98.0         |
|         | 7      | 0.926                  | 4.51                     | 2.8                              | 0.0          | 99.0         |
|         | 9      | 0.578                  | 6.99                     | 3.2                              | 0.0          | 99.0         |
|         | 11     | 0.599                  | 9.32                     | 3.6                              | 0.0          | 99.0         |
|         | 12     | 0.533                  | 12.92                    | 3.9                              | 0.0          | 99.0         |
| SW      | 1      | 0.036                  | 0.16                     | 4.5                              | 1.0          | 99.0         |
|         | 2      | 0.128                  | 0.44                     | 2.7                              | 0.0          | 99.0         |
|         | 3      | 0.188                  | 1.01                     | 2.9                              | 0.0          | 99.0         |
|         | 4      | 0.278                  | 1.58                     | 2.5                              | 0.0          | 99.0         |
|         | 7      | 0.942                  | 4.65                     | 3.0                              | 8.0          | 91.0         |
|         | 9      | 0.684                  | 7.27                     | 3.2                              | 0.0          | 91.0         |
|         | 11     | 0.571                  | 10.34                    | 3.7                              | 0.0          | 91.0         |
|         | 12     | 0.527                  | 13.42                    | 4.0                              | 0.0          | 91.0         |
Figure 1. Cumulative average values of production costs per bird obtained in the evaluated houses (R$ bird⁻¹). * Considering starter feed (R$2.00 kg⁻¹) and grower feed (R$1.80, kg⁻¹). ** Considering a monthly income as the minimum per capita wage (R$998.00). *** Considering Coelba's rural tariff (R$0.39, kWh⁻¹) for the 15 days of night heating.

Figure 2. Average values of profitability per bird obtained in the sheds (R$ bird⁻¹), considering the sale of live free-range chickens for R$12.00 kg⁻¹.

Figure 3. Average values of profitability per bird obtained in the sheds (R$ 17ird-1), considering the sale of live free-range chickens for R$12.00 Kg⁻¹, for 205 birds in SM (A) and 217 birds in SW (B).

Figure 4. Average values of profitability per bird obtained in the sheds (R$ bird⁻¹), considering the sale of live free-range chickens for R$12.00 kg⁻¹, for 411 birds in SM (A) and 600 birds in SW (B).

Figure 5. Average values of profitability per bird obtained in the sheds (R$ bird⁻¹), considering the sale of live free-range chickens for R$12.00 kg⁻¹, for 600 birds in both sheds.
Figure 1

Masonry Shed (SM)

Wooden shed (SW)

Other production costs:

Acquisition of the animals:

- $200.00

Medication:

- $50.10/bird

Electricity:

- $5.00/day

Cost involved (RS)

Time (Days)

---

4  11  18  25  46  60  88

---

4  11  18  25  46  60  88

---

- Labor Worksheet
- Feeding

---

- Labor Worksheet
- Feeding

---

RETRACTED
Figure 2

![Graph showing the rentability of Masonry Shed (SM) and Wooden Shed (SW) over time.](Image)

- **Masonry Shed (SM)**
- **Wooden Shed (SW)**
Figure 4

(A) Rentability (RS h⁻¹)

(B) Rentability (RS h⁻¹)

Time (Days)
Figure 5

![Graph](image_url)

- Masonry Shed (SM)
- Wooden Shed (SW)