

A COMPARISON OF PRODUCTION AND ECONOMIC PERFORMANCES OF BROILERS RAISED UNDER NATURALLY VENTILATED OPEN-HOUSE AND TUNNEL VENTILATED CLOSED-HOUSE SYSTEMS IN SRI LANKA

NSBM Atapattu^{1*}, LM Abeywickrama², WWDA Gunawardane¹ and M Munasinghe³

¹Department of Animal Science, ²Department of Agricultural Economics, Faculty of Agriculture, University of Ruhuna, Mapalana, Kamburupitiya, Sri Lanka

³Munasinghe Institute for Development, N.10 De Fonseka Road, Colombo, Sri Lanka

ABSTRACT

The objective of this study was to compare production and economic performances of broilers raised under naturally ventilated open house (OH) and tunnel ventilated-closed house (CH) conditions in Sri Lanka. The analysis used production and economic parameters of 130 OH (130 farms) and 88 CH (5 farms) production cycles. Open house farms were selected using proportionate random sampling technique while closed houses were purposively selected. The sum of the Percentages of mortalities and disable birds was significantly higher under OH system compared to that under CH system. The most vulnerable periods for the losses due to mortalities were the first week and from day 29-35 of the growing cycle. The mean length of the growing cycle under OH (38.4 days) was significantly higher than that of CH (34.6 days). OH operators reported a significantly lower number of growing cycles/year (4.4) with a longer clean-out period (44 days) compared to CH (6.9 cycles/year and 18 days, respectively). Production performance indicators such as mortality (3.3%), final live weight (1974 g), feed conversion ratio (1.56), performance efficiency factor (356) of broilers under CH were significantly better than those under OH system (4.5%, 1922 g, 1.94 and 254, respectively). Cost of feeds and day-old-chicks accounted for 74.7 and 23, and 66.6 and 24% of the total variable costs of OH and CH, respectively. Raising of broilers under CH conditions recorded significantly lower total cost (Rs 440), higher net profit (Rs 85.6 bird⁻¹ and unit profitability (Rs 46.8 m⁻² day⁻¹) than under OH (Rs 453 and Rs 58.9, Rs 13.2 m⁻² day⁻¹, respectively). Production and economic performance indicators and resource utilization efficiencies (temporal and spatial) of broiler production were concluded to be significantly better under CH than OH system. Though production performance parameters of the broiler production, particularly under CH systems were comparable with those of countries having well-developed poultry industries; feed and day-old-chick costs were higher in Sri Lanka.

Key words: Broiler, Closed-house, Economic, Open-house, performance

INTRODUCTION

Reporting 8 kg of annual per capita consumption, poultry meat is the most popular livestock product, across all ethnic and religious communities in Sri Lanka (National Livestock Statistics Bulletin, 2016). Importantly, demand for poultry meat has been predicted to increase at a higher rate than that for other meat types (Henchion et al., 2014). In these circumstances, Sri Lankan poultry industry firstly has to meet the growing demand for poultry products at an affordable price while respecting social values and concerns. Secondly, the industry has

to comply with and be competitive in the international market in terms of its' financial, environmental, and animal welfare aspects so that the industry could make a higher contribution towards the national economy. These challenges demand a sustainable development of the industry. A better scientific understanding about the production, economic, environmental and social performance of the existing poultry production systems is a prerequisite for such an endeavor.

Naturally ventilated open-house (OH) and tunnel ventilated closed-house (CH) systems

*Corresponding author: mahindaatapattu@gmail.com

are the most popular broiler production systems in Sri Lanka. Open-house system is widely practiced by a vast majority of small and medium scale farmers. In a typical naturally ventilated open house, there are short side walls above which wire nets are fixed to maximize natural ventilation. There may be a moveable curtain which covers the wire-net. When necessary, the curtain is opened to control the inside conditions such as temperature, humidity and air circulation. Birds are reared as flocks of varying sizes on a litter material for manure collection. Open houses may be single or multi-tired. Open house systems are popular in tropical areas where heating is not needed, except during brooding (Spahat, 2014). Despite the popularity of CH, particularly during the last two decades, according to industry information, broilers reared under OH systems accounted for 78% of the production (Hatchery Industry Information; as of May 2018).

Modern broiler strains grow very fast at a remarkably high feed conversion efficiency under specific nutrient and environmental conditions. Provision and maintenance of those environmental conditions are difficult, particularly when a large number of birds are reared. Closed-house system allows more birds are reared in one house under optimum environmental conditions. Closed house is an enclosed environment in which floor is covered with a litter material or carpet to collect manure. The increase of heat, moisture, odorants, ammonia and other noxious gasses inside the cage is prevented by a ventilation system which is often electronically regulated. The ventilation system consists of fans, air inlets, evaporative cooling system and controllers/thermostats. Sometimes, fogging nozzles are provided, spraying a fine mist of water to lower the air temperature (Lacey et al., 2004).

A Malaysian (Spahat, 2014) and a Philippine (Levy, 2017) studies reported better growth performance under CH system than OH system. Disanayaka et al. (2015) reported higher edible meat yield, breast meat percentage, drumstick

meatiness for the broilers kept in CH compared to OH. System-level comparisons on production and economic performance of broilers rearing under Sri Lankan OH and CH conditions are scarce. Hence, the present study while comparing the production and economic performances of Sri Lankan OH and CH broiler production systems, discusses the same with those of countries having well-developed broiler industries.

MATERIALS AND METHODS

Sampling procedure

Proportionate purposive sampling technique was used to select 130 broiler farms that kept birds under OH conditions. The number of broiler farms that should be selected from each District was determined according to the total number of farms in the respective District (Livestock Statistics Bulletin of Sri Lanka, 2015). Farms within a District were purposively selected considering the following factors.

- 1). The farm should have been operated at least 2 cycles during the previous year.
- 2). Required information should be available, reliable and accessible or farmer should be cooperative and helpful in collecting data.
- 3). Proportionate allocation of farms according to the number of small and larger farms. However, due to the above factors (1 and 2), the number of farms selected from small farms was less than that should be.
- 4). Care was taken to represent both independent and contract farmers. However, contract farmers had to be selected only from 8 Districts where the system was in practice.

Data related to one production cycle of each farm was recorded during January-December 2016. Information related to growth and economic performance was collected using farm records (when available), semi-structured-type questionnaire, and informal discussions with the farmer. All farms obtained day-old chicks (Cobb 500, Hubbard or Indian River) from reputed hatcheries and fed commercial broiler feeds. The commercial brands of day-old

chicks and feed used by the selected farms cumulatively accounted for 90% and 80% of the market shares in respective sectors in Sri Lanka.

The CH farms were also purposively selected mainly on the accessibility to data/information. Information about 88 production cycles of 5 commercial CH farm was collected. All farms had 400 ft x 40 ft tunnel ventilated houses with cooling pads.

Determination of growth performance parameters

Following performance evaluation indicators were used

1). Mortality and disable/culled birds %

$$\frac{\text{Total feed intake}}{\text{Final live weight out}}$$

2). Feed conversion ratio=

3). Performance efficiency factor=

$$\frac{\text{Live weight (Kg)} \times \text{Liveability (\%)} \times 100}{\text{Growing cycle (days)} \times \text{FCR}}$$

Determination of economic performance indicators

1) Unit profitability (Rs m⁻² day⁻¹) =

$$\frac{(\text{Income from birds m}^{-2}) - (\text{All cost m}^{-2})}{\text{Cycle length (days)}}$$

2) Gross profit/bird = Total income by selling bird - Total variable cost

Following cost items were considered in gross profit analysis. m²

Feed cost (Rs/kg), Medication cost/bird, Day old chick (Rs/chick), Litter material cost (Rs/bird), Electricity cost (Rs/bird), Labour cost (Rs/bird), Catching cost (Rs/bird), Loan interest (Rs/bird).

Net profit= (Total income – Total cost including loan repayment on investment)

A description of cost items considered is given in Table 1.

4) Profitability index = $\frac{\text{Net profit}}{\text{Total revenue}}$

Main income source was the selling of broilers on live weight. The national average val-

ue (266.42 Rs/kg live weight) as of Livestock Statistics Bulletin (2016) was taken for the total revenue calculation.

Statistical analysis

Means of continuous variables of OH and CH were compared using two sample t-test on MINITAB Ver 14. Differences were considered when p<0.05.

RESULTS AND DISCUSSION

Production performance

A comparison of the production performance of broilers reared under OH and CH conditions are given in Table 2. As expected, the number of birds/cycle under OH conditions was significantly lower than that of CH but varied widely (from 150-28000).

Stocking density and production per unit area

Contrary to the Sri Lankan industry recommendation of 930 cm² (1 square foot), it was found that broilers in OH and CH systems received 1305 and 533cm² of floor space per bird, respectively. Approximately similar space allowances have been reported by Ekwue *et al.* (2003) for CH (600 cm²/bird) and OH (1000 cm²/bird) broiler production systems in Trinidad. Under OH conditions, removal of birds due to mortalities further increased the floor area upto 1730 cm²/bird by day 40, while impact of mortality on floor area increase was low (from 533-560cm²/bird) under CH conditions. Under CH conditions, commencement of catching as early as day 30 substantially increased the per bird space allowance for remaining birds. This practice helped to secure a high initial stocking density while ensuring sufficient space allowance during the later stages of the growing cycle. Live weight production/m² under OH conditions (14 kg) was significantly lower than that of CH (35 kg). However, Committee of the European Union Welfare Directive (2005) recommended a minimum space allowance that corresponds to 33 kg m⁻². Therefore, though Kryeziu *et al.* (2018) suggested that spacing

Table 1:A description of the cost items considered in economic analysis.

Cost category	Cost item	Remarks	
Variable	Day old chick	National average value of 2016 ¹ =104.38Rs/chick	
	Feed	National average values of 2016 ¹ , Booster/starter=98.48 ¹ , Finisher=93.52	
	Litter material	Amount used and price determined using the survey	
	Drugs/medicines other supplements	Material used, dosages and price determined using the survey	
	Electricity	Meter readings, bills or estimated (KWhrs) according to the appliances and duration used. Then back calculated to Rs/bird according to national electricity bill payment schedule	
	Labour	Family labour of OH not considered. CH, direct farm labour/supervisory staff and security only, excluded the admin and clerical staff. Labour day=1000 Rs, supervisory level labour day=1500 Rs	
	Catching	Only for CH, determined on industry information	
	Interest	OH Land cost was not considered. Construction cost of the existing house (Rs ft ²) was compared with a set standard value (400 Rs ft ²) of a shed (concrete floor, open-sided, corrugated metal roof with heat protection underlining, 30 cm brick side wall). Then the value of the shed was estimated by multiplying the estimated value/ft by the shed area. Assuming farmer obtained a loan to the shed at 10% flat interest to pay in 5 years, due monthly interest was estimated. CH Based on the industry information, it was estimated that 400 x 40 ft house with equipment cost 1.7 Rs Mil. Monthly interest was estimated for a loan of 1.7 Rs Mil obtained at 10% of flat interest to repay in 10 years.	
	Fixed	Loan payment on investment	OH Investment was estimated as above. Monthly installment was calculated using equation given below ² .
			CH Investment was estimated as above Monthly installment was estimated using equation below ² .

¹Livestock Statistics Bulletin, 2016.

$$^2\text{Annual loan repayment (Rs)} = \frac{Pm r (1+r)^n}{(1+r)^n - 1}$$

Where

Pm= Initial investment, r= interest rate and n= repayment period (years)

under CH conditions could be reduced even up to 450 cm²/bird, further reduction of space allowance under Sri Lankan CH conditions cannot be recommended due to possible wel-

fare implications. Recent findings of Farhadi *et al.* (2016), that showed no growth performance difference between broilers grown in CH at higher stocking density (470 cm²/bird)

and those under OH at lower stocking density (615cm²/bird) also caution the use of higher stocking densities under CH. With regard to

OH systems as well, it may be suggested that OH system could have been more productive

Table 2: A comparison of the production performance of broilers under Sri Lankan naturally ventilated open-house and tunnel ventilated closed-house conditions.

Parameter	Production system		P-value
	Open house	Closed-house	
Birds per cycle	3559±6156 (150-28000)	29311±3421 (22000-32500)	0.001
Cycles/year	4.4±0.7	6.9±0.5	0.001
Clean out period	44.3±18	18.3±5	0.001
Mortality and disable birds (%)	0-7 day	2.75±4.79	0.99±0.57
	8-14 day	0.54±0.87	0.56±0.25
	15-21 day	0.43±0.65	0.53±0.26
	22-28 day	0.48±0.78	0.47±0.23
	29-35 day	0.98±1.55	0.68±0.37
	36-42 day	0.05±0.10	0.09±0.23
	Total period	4.52±3.75 (0.5-31.4)	3.36±1.59 (1.27-9.25)
Days to slaughter	38.4±1.96 (32-42)	34.6±1.65 (30-39)	0.01
Live weight at slaughter	1922±110	1974±190	0.02
Birds/m ² (final)	7.3±2.2	18.1±2.1	0.001
Kg live weight production /m ²	14.0±4.4	35.7±4.9	0.001
Total feed intake (g/d)	97.0	89.0	0.001
Farms that used 2 phase feeding (%)	77	77	Not applicable
Farms that used 3 phase feeding (%)	23	23	
Farms that did not use booster feed (%)	20	21.5	
Farms that did not use starter feed (%)	57.5	56.8	
Booster feed in total feed intake (%)	23.1±17	26.6±21.4	0.23
Starter feed in total feed intake (%)	10.8±14.4	12.3±16.9	0.50
Finisher feed in total feed intake (%)	66.1±9.7	61.1±11.2	0.45
Weight gain (g/day)	50.18	57.15	0.01
FCR	1.94±0.30	1.56±0.18	0.001
Performance efficiency factor	254±52	356±58	0.001
Unit profitability (Rs m ⁻² day ⁻¹)	13.20±13.9	46.80±25.5	0.000
Profitability index	0.11±0.10	0.16±0.07	0.00

had more birds were raised per unit area. However, adverse impacts of high temperature and poor management conditions on growth, health, welfare and ammonia emission could have been higher had the stocking density was high under OH conditions. Therefore, the provision of a higher space allowance given under OH conditions can be viewed as a compromise between stocking density and the adverse impacts of poor environmental and management conditions. The results of the present study suggest that both OH and CH systems utilizes the available floor area efficiently, by strategically maneuvering the conditions.

Mortalities and disable birds

The sum of the percentages of mortalities and disable birds was significantly ($P < 0.01$) higher under OH system compared to that under CH system. It was observed that the most vulnerable periods for the losses due to mortalities were the first week and from day 29 to 35 of the growing cycle. Indicating the importance of improving management and environmental conditions of OH system, mortality and disable birds during the first week was three times higher under OH compared to CH conditions. Early stage mortalities can be viewed as a loss of a potential income while that of later stages of the production becomes a loss of potential income at a higher cost. Therefore, though mortality values reported herein fall well within those reported in numerous field surveys (Table 3), further reduction of mortality should be a high priority, particularly for OH system.

Growing cycle length

The mean length of the growing cycle under OH (38.4 days; range 32 days to 42 days) was significantly higher than that of CH (34.6 days). Open house operators reported a significantly lower number of growing cycles (4.4) than CH (6.9). Even among relatively more established OH farmers, the number of growing cycles per year was influenced by a number of factors including the availability of

chicks and market situations. Consequently, the calculated mean clean-out period of OH system (44 days) was significantly higher than that of the CH (18 days). Longer growing cycles increases the return per bird while shorter cycles permit a higher number of harvests per year. For example, Kleyn (2002) showed that a 38-day growing cycle with an 11-days of clean out period allows an extra cycle per year compared to the practice of 42 day cycles with 14-day intervals.

The traditional broiler management practice in Sri Lanka adopts 42 days growing period and 14 days of clean-out period (Samarakoon and Samarasinghe, 2012), allowing 6.5 cycles per year. Had it operated with 34.6 days of growing cycle and 14 days of clean out period, the CH system could have had a maximum of 7.5 cycles per year. Therefore, as far as temporal utilization of facilities is concerned, CH system is concluded to be operated at closer to its maximum efficiency (92%). Similarly, had OH system operated with 38.4 days of growing cycle with 14 days of clean out period, the system could have operated 6.9 cycles per year. Accordingly, the temporal utilization efficiency of facilities is estimated to be as low as 46.7%.

Feed intake and feed conversion efficiency

Contrary to Al-Marzooqi *et al.* (2010) who reported 4.7% feed intake reduction for 35 days of growing cycle in OH compared to CH, in the present study feed intake under OH system was 8.9% higher than that of CH conditions. The fact that under OH conditions, birds were kept approximately four more days during which feed intake is high partly explains the above observation. Furthermore, all the CH operations had automated line feeders and adapted a better feeding system management practices. In contrast, apart from 8 farms all other OH operations used bell-shaped feeders and feeding system management was of lesser intensive, leading to more feed wastage. Percentage contributions of the booster, starter, and finisher feeds to the total feed in-

takes were not significantly different between two systems (Table 2) and the proportion of each feed in total feed intake (15, 26 and 59%, respectively) were similar to that reported by Dong *et al.* (2011). Despite the availability of broiler diets for adopting three phas-

es feeding program, only 77 and 23% of the CH and OH, respectively practiced three phase feeding regimen. Around 58 and 20% of the farmers skipped either starter or booster diet, respectively.

Table 3: Growth performance parameters of naturally ventilated open-house and tunnel ventilated closed-houses systems reported in recent comparable studies.

Study	Country	Analysis	System	Mortality (%)	FCR	PEF
		This study	OH	4.52	1.94	254
			CH	3.36	1.56	356
van Horne (2017)	EU	National average	CH		1.66	
	USA		CH		1.86	
	Thailand		CH		1.68	
	Brazil		CH		1.79	
Spahat (2014)	Malaysia	Field survey	OH	6.8	1.91	
			CH	3.6	1.78	
Lallo <i>et al.</i> (2012)	Trinidad	Experimental conditions	OH	4.7	2	.10
Ekwue <i>et al.</i> (2003)	Jamaica	Experimental conditions	CH	1.5	1.90	
Ullah <i>et al.</i> (2017)	Pakistan	Field survey	OH		1.62	
Farhadi <i>et al.</i> (2016)	Pakistan	Comparison between OH and CH	CH		1.88	
			OH		1.98	
Kamberi <i>et al.</i> (2018)	Kosavo	Experimental conditions	CH	0.46	1.79	267
Kadim <i>et al.</i> (2008)	Oman	Experimental conditions	CH		1.71	
			OH		1.79	
González-García <i>et al.</i> (2014)	Portugal	LCA, one farm	CH		1.70	
Pelletier (2008)	USA	LCA	CH		1.91	
Kraatz <i>et al.</i> (2013)	UK	Farm level determination	CH		1.74	
Castellini <i>et al.</i> (2012)	Italy	LCA	CH	3.8	1.9	
Bokker and de Boer (2012)	Netherlands	Farm level determination	CH	3.3	1.73	
Al-Marzooqi <i>et al.</i> (2010)	Oman	Under experimental conditions	CH		1.66	
Al-Marzooqi <i>et al.</i> (2010)	Oman	Experimental conditions	OH		1.76	
Levy <i>et al.</i> (2017)	Philippine	4-year field trial	OH		1.82	
			CH		1.78	
Tandoğan and Çiçek (2016)	Turkey	Field survey	OH	7.00	1.80	298
Samarakoon and Samarasinghe (2012)	Sri Lanka	Experimental conditions	OH			200
Kryeziu <i>et al.</i> (2018)	Kosavo	Experimental conditions	OH	0.65	1.64	290

Despite higher feed intake, broilers under OH showed significantly lower growth performance parameters such as age at slaughter (38.4 days), final live weight (1922 g) and FCR (1.94) compared to those under CH conditions (34.4days, 1974g, 1.56). FCR values of both production systems distributed normally (Fig 1). Interestingly, Sri Lankan CH system has achieved better FCR values than those reported in many recent studies (Table 3). FCR value under Sri Lankan OH conditions is at least comparable with or sometimes better than those reported elsewhere. However, a potential of achieving better performance even under Sri Lanka OH conditions are indicated by the fact that more than 50% of the Sri Lankan OH farmers had reported a FCR value less than 1.9 (Fig 1).

Performance efficiency factor

Compared to FCR, Performance efficiency factor (PEF) better describes farm's overall production performance since a number of performance parameters (feed intake, final live weight, mortality and the length of the

growing cycle) are simultaneously taken into account. PEF achieved by Sri Lankan broiler production under CH conditions is comparable with that of the leading broiler producing countries (Table 3). Meanwhile, reflecting inferior performance with respect to all the above parameters, Sri Lankan OH operators reported significantly lower PEF than CH. The PEF values reported herein for OH is better than that of earlier Sri Lankan study (Samarakoon and Samarasinghe, 2012). Meanwhile, indicating possibilities for further improvements in OH, Tandoğan and Çiçek (2016) and Kryeziu *et al.*(2018) have reported higher PEF values for Turkish and Kosovo OH sector, respectively.

Economic performance

Cost items

Main cost items incurred in broiler production under OH and CH conditions in Sri Lanka are given in Table 4. Variable cost under OH conditions was as high as 97.8% of the total cost while the same was 96.8% for CH. Under OH conditions cost of labour, medications, elec-

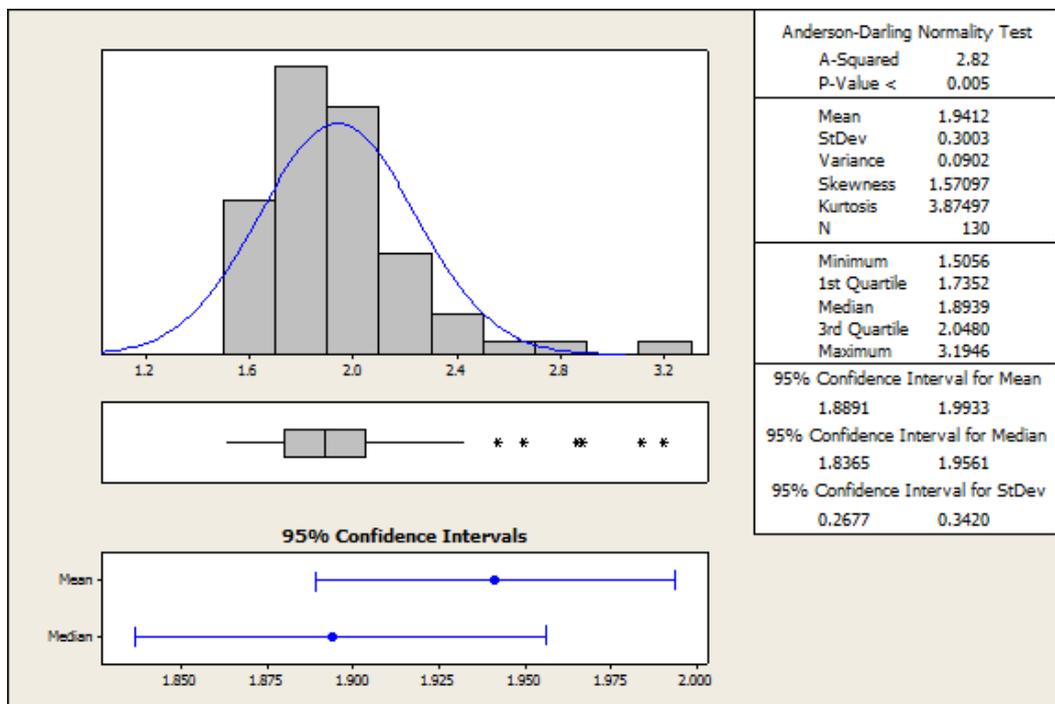


Figure 1: Feed conversion ratio of broiler production under naturally ventilated open-house conditions.

tricity and loan repayment per bird was significantly lower than those under CH conditions. Many of the OH farms were operated by family labour with minimum hired labour. Therefore, labour cost could have been higher had family labour (which was estimated to be 21.6 labour days/1000 birds) was also considered. Estimation of the loan repayment cost of OH farmers assumed that all farmers had obtained loans on similar repayment conditions. The estimated per bird fixed cost (loan repayment) for CH conditions was 13 times higher than that of OH.

In gross margin analysis, due interest calculated on 10% flat rate of interest, payable in 5 (for OH) and 10 years (for CH), respectively for OH and CH was considered. Due interest in investment for the production of broiler under CH was 6.6 times higher than that of OH. Catching incurred 7.40 Rs /bird under CH whereas it incurred little cost under OH conditions, which included in total labour cost.

Despite the lower cost incurred on the above items, raising of broilers under OH conditions

recorded significantly higher total cost per bird, mainly due to the higher feed cost/bird. Irrespective of the production system, feed cost followed by the cost for day-old chick was the largest cost items. Feed and day-old chicks alone accounted for 97.5% and 89.2% of the total cost of production of OH and CH farms, respectively (Fig 3). Irrespective of the level of development of broiler industry, feed cost has been identified the largest cost component (van Horne 2017; Ullah *et al.*, 2017; Rana *et al.*, 2013; Bano *et al.*, 2011). However, compared to Sri Lanka, the share of feed cost in total cost is reported to be lower in countries such as EU, USA, Turkey, Brazil, and Thailand (Table 5). Interestingly, the above countries are among the largest global broiler producers and exporters.

Cost on medications and disinfectants being the third largest cost item, contributed 4.1% to the total cost of production under CH conditions. Therefore, cheaper health and hygiene management interventions that do not adversely affect growth performance are also important, particularly for CH operators.

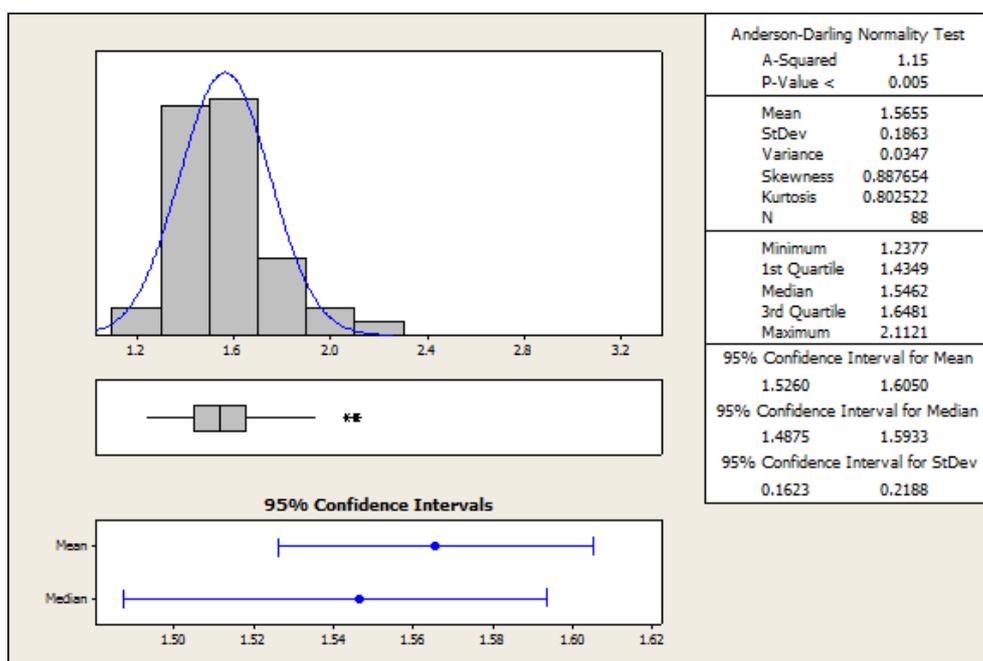


Figure 2: Feed conversion ratio of broiler production under Sri Lankan tunnel ventilate closed-house conditions.

The total cost of production of broilers in OH was significantly higher than in CH. Conversion of the cost of production into eurocents (1Euro=180 Sri Lankan Rupees as of June 2016) showed that Sri Lankan OH and CH systems incurred as high as 131 and 121 eurocents/Kg live weight (Table 5). Feed cost, day-old chick cost and total cost of production in Sri Lanka were substantially higher than those

in EU, USA and other countries such as Thailand, Brazil and Turkey with which Sri Lankan broiler industry showed comparable growth performance parameter (Table 3). Therefore, even though the growth performance is comparable with international standards, higher cost of production makes Sri Lankan broiler industry less competitive in export markets. Results of this study highlight

Table 4: Growth performance parameters of naturally ventilated open-house and tunnel ventilated closed-houses systems reported in recent comparable studies.

Item No	Item	Rs/bird		P value
		OH	CH	
Variable cost items				
1	Feed	337.9±50.5	284.3±39.4	0.00
2	Day old chick	104.38	104.38	
3	Disinfectants/drugs/litter amendments/vaccines/water purifier	6.44±1.83	17.96±0.51	0.00
4	Labour	2.40±4.60	6.02±0.07	0.00
5	Litter material	0.80±0.7	0.46±0.18	0.00
6	Electricity	0.14±0.04	5.92±0.33	0.00
7	Catching		7.40±0.47	
Total variable cost	451.10±49.9	426.5±39.30	0.00	
Percentage	99.75	96.80		
Fixed cost items				
8	Loan repayment	1.08±0.39	13.83±1.66	0.00
Percentage	0.25	3.2		
Net profit analysis				
	Total cost	453.20±50.00	440.30±40.81	0.00
	Income (selling birds)	512.0±29.30	525.90±39.80	0.00
	Profit per bird	58.9±55.80	85.60±45.60	0.00
Gross profit analysis				
	All cost item excluding item 8	452.10±49.9	427.00±39.40	0.00
	Loan interest (10% fixed rate, 5 and 10 years period for OH and CH, respectively)	0.08±0.03	0.53±0.06	0.00
	Total variable cost	452.20±50.0	427.60±39.3	0.00
	Total income	512.0±29.30	525.9±39.80	0.00
	Gross profit per bird	59.80±55.70	98.30±45.40	0.00

the importance of lowering the day-old chick price and most critically the feed cost to make broiler meat more affordable to local consumers and competitive in the international market.

Profitability

In line with the global trend for several decades both in developed (Davis, 2015) and developing countries (Rana *et al.*, 2012), broiler production in Sri Lanka was also found to be profitable (Table 4). Both gross and net profit for the raising of broilers under CH conditions was significantly higher for CH than OH. Per bird net profit under CH was 1.45 times higher than that under OH conditions. Ekwue *et al.* (2003) reported that profit under CH conditions was two and a half times higher than that of OH. Due to higher investment cost, the difference between gross and net profit was small for CH than OH conditions. Since the analysis considered the same prices per kg of feed for both production systems, the higher financial performance achieved by CH is mainly attributed to the better growth performance. Since the genetic potential of the chicks and the feeds used in both systems are similar, improved performance is mainly a result of better controlled environmental and general management conditions that birds received under CH. Numerous studies (Kaur *et al.*, 2017; Gillespie *et al.*, 2017; Levy, 2017; Farhadi *et al.*, 2016; Liang, *et al.*, 2013), have emphasized that environmental conditions-controlled better housing is crucial

in achieving genetic and nutritional potentials. Though provision of improved conditions incurred higher initial investment, production efficiency improvements and larger scale of operations ultimately made CH systems financially more profitable than OH.

CONCLUSION

Growth performance parameters of broilers under CH systems were found to be significantly better than those under OH system. Compared to OH, CH system utilized the available housing spaces more efficiently. Temporal utilization efficiency of resources was also significantly better under CH, compared to OH conditions. Irrespective of the production system, broiler farming was of an economically profitable industry. Despite

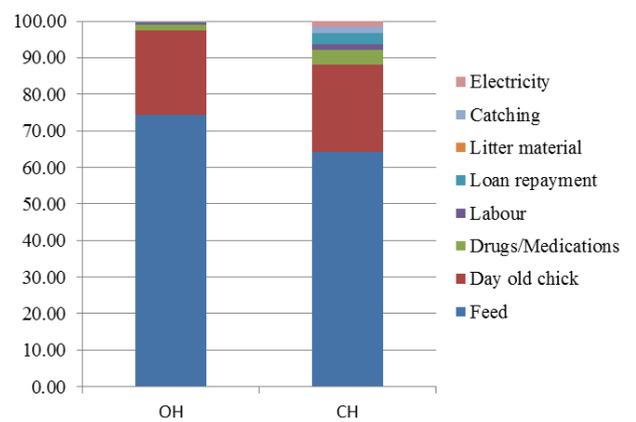


Figure 3: Percentage contribution of different cost items to the total cost of production of broilers under naturally ventilated open-house and tunnel ventilated closed-house conditions.

Table 5: Cost of broiler production in Sri Lanka and some selected countries.

Cost item	Country					
	Sri Lanka (this study) (Euro=180 Rs)	EU ¹	USA ¹	Thailand ¹	Brazil ¹	Turkey ²
Day old chick	57.7	15.2	9.8	12.6	9.4	15
Feed	102 (for OH) 80 (for CH)	54.2	48.8	52.9	47.7	71
Total cost	131 (for OH) 124 (For CH)	86.4	68.6	76.6	62.2	107

1. van Horne (2017); 2.Tandoğan and Çiçek (2016)

higher electricity, labour, drug and medication costs, total production cost per broiler was low under CH conditions, due mainly to its better growth performance parameters. Though growth performance parameters of broilers, particularly under CH systems were comparable with those of countries having well-developed poultry industries, feed and day-old-chick costs were found to be higher in Sri Lanka than the countries.

REFERENCES

- Agency for Toxic Substances and Disease Registry (ATSDR, 2003). "Public Health Statement for Atrazine". Toxic Substances Portal - Atrazine. Center for Disease Control, Agency for Toxic Substances and Disease Registry, Division of Toxicology and Human Health Sciences. Retrieved May 2, 2015.
- Al-Marzooqi W, Al-Farsi MA, Kadim IT, Mahgoub O and Goddard JS 2010 The effect of feeding different levels of sardine fish silage on broiler performance, meat quality and sensory characteristics under closed and open-sided housing systems. *Asian-Australas J. Anim Sci.* 23:614-1625.
- Bano R, Shah H, Sharif M and Akhtar W 2011 Profitability index and capital turn over in open house broiler farming: a case study of district Rawalpindi. *Pak. J. Agric. Res.* 24.
- Bokkers EAM and de Boer IJM 2009 Economic, ecological, and social performance of conventional and organic broiler production in the Netherlands. *Brit. Poult. sci* 50(5), pp.546-557.
- Castellini C, Boggia A, Cortina C, Dal Bosco A, Paolotti L, Novelli E and Mugnai C 2012 A multicriteria approach for measuring the sustainability of different poultry production systems. *J. Clean Prod.* 37:192-201.
- Commission of the European Communities 2005 Laying down minimum rules for the protection of chickens kept for meat production. *COM Proposal 221* Available at: <https://www.ecolex.org/details/legislation/council-directive-200743ec-laying-down-minimum-rules-for-the-protection-of-chickens-kept-for-meat-production-lex-faoc072633/> [Accessed on 20th Aug 2018]
- Davis CG 2015 Factors Influencing Global Poultry Trade. *International Food and Agribusiness Management Review*. 18: Special Issue A.
- Disanayaka NMTS, Munasinghe MAJP, Bandara RMAS, Liyanage LAN and Disanayake PDC 2015 Meat Yield of the Strains Cobb 500, Hubbard Classic, Hubbard Flex, Hubbard 15 under Open and Close House Condition. *Sabaragamuwa University Journal*, 14(1).
- Dong H, Zou Z, Zhu Z, Xin H, Chen Y 2011 Carbon and nitrogen budget of commercial cage-grown broilers. *ASABE, St. Joseph, USA. ASABE Annual International Meeting, Louisville, August 10.*
- Ekwue EI, Gray M, and Brown A 2003 Poultry Farm Building in Trinidad: Present and Future Prospects. *West Indian J. Engineering*. 25:1-7.
- Farhadi D, Hosseini SM and Dezfuli BT 2016 Effect of house type on growth performance, litter quality and incidence of foot lesions in broiler chickens reared in varying stocking density. *J. Bio Sci. Biotech.* 5.
- Gillespie J, Nehring R and Hallahan C 2017 New versus old broiler housing technology: Which leads to greater profit. *J. Appl. Poul. Res.* 26:72-83.
- González-García S, Gomez-Fernández Z, Dias AC, Feijoo G, Moreira MT and Arroja L 2014 Life Cycle Assessment of broiler chicken production: a Portuguese case study. *J. Clean Prod.* 74:125-134.
- Henchion, Maeve, Mary McCarthy, Virginia

- C. Resconi, and Declan Troy 2014 Meat consumption: Trends and quality matters. *Meat science* 98,3: 561-568.
- Kadim IT, Al-Qamshoui B, Mahgoub O, Al-Marzooqi W and Johnson EH 2008 Effect of seasonal temperatures and ascorbic acid supplementation on performance of boiler chicken reared in closed and open-sided houses. *Int. J. Poult.Sci.*7:655-660.
- Kamberi MA, Berisha S, Mestani N and Kryeziu AJ 2018 The European performance indicators of broiler chickens as influenced by stocking density and sex. *Agro Res.* 16:483- 491.
- Kaur M, Sharma A, Gupta R, Singh Y, Sethi APS and Singh C 2017 Resource use efficiency of broiler production in tunnel-ventilated environmental control vis-à-vis open-sided conventional shed during summer. *Trop. Anim. Health Pro.*49:1591-1596.
- Kleyn R 2002 Strategies for managing expensive feed on farm. Available at www.spesfeed.co.za/Strategies_for_managing_Expensive_Feed_on_Farm. [Accessed on 08 March 2009]
- Kraatz S, Sinister JC and Reinemann DJ 2013 Energy intensity and global warming potential of corn grain ethanol production in Wisconsin (USA). *Food and Energy Security.* 2:207-219.
- Kryeziu AJ, Mestani N, Berisha S and Kamberi MA 2018 The European performance indicators of broiler chickens as influenced by stocking density and sex. *Agro Res.* 16:483-491.
- Lacey RE, Mukhtar S, Carey JB and Ullman JL 2004 A review of literature concerning odors, ammonia, and dust from broiler production facilities: 1. Odor concentrations and emissions. *J. Appl. Poult. Res.* 13:500-508.
- Lallo CH, Williams M, Campbell M and Palmer DW 2012 The effect of stocking density on the performance and economic implications for broilers grown to 42 days in open sided house in Trinidad. *Tropi.Agric-Trini.* 89:170.
- Levy KK 2017 Comparative Productivity Analysis of Broiler under Climate Controlled System and Conventional Housing in Selected Municipalities of Nueva Ejica: Philipines. *IOSR J. Economics and Finance.* 8:39-48.
- Liang Y, Kidd MT, Watkins SE and Tabler GT 2013 Effect of commercial broiler house retrofit: A 4-year study of live performance. *J. Appl. Poult. Res.* 22:211-216.
- National Livestock Statistics Bullateine. 2015 Department of Animal Production and Health, Sri Lanka. [Online] Available at: http://www.daph.gov.lk/web/images/content_image/publications/other_publications/stat_bulletin_2015.PDF
- National Livestock Statistics Bullateine 2016 Department of Animal Production and Health, Sri Lanka. http://www.daph.gov.lk/web/images/content_image/publications/other_publications/stat_bulletin_2015.PDF
- Pelletier N 2008 Environmental performance in the US broiler poultry sector: Life cycle energy use and greenhouse gas, ozone depleting, acidifying and eutrophying emissions. *Agri. Sys.*98:67-73.
- Rana KAM, Rahman MS and Sattar MN 2013 Profitability of small scale broiler production in some selected areas of Myensingh. *Prog.Agri.* 23:101-109.
- Samarakoon SMR and Samarasinghe K 2012 Strategies to improve the cost effectiveness of broiler production. *Tropic. Agri. Res.*23:338-346.
- Spahat N 2014 Environmental impact of different production systems and consumer willingness to pay for chicken meat produced with a higher regard for the environment. PhD Thesis, Newcastle

university, UK.

Tandoğan M and Çiçek H 2016 Technical Performance and Cost Analysis of Broiler Production in Turkey. *Revista Brasileira de Ciência-Avícola*.18:169-174.

Ullah I, Ali S, Khan SU and Sajjad M 2017 Assessment of technical efficiency of open shed broiler farms: The case study of Khyber Pakhtunkhwa province Pakistan. *J. Saudi Society of Agric. Sci.*

vanHorne PLM 2017 Competitiveness of the EU poultry meat sector, base year 2015 International comparison of production costs. Wageningen, Wageningen Economic Research, Report 2017-005. Available at: https://www.wur.nl/upload_mm/3/1/c/6ad68417-86de-47d8-a925-.pdf [Accessed on 10th Sep 2018]