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Relationship between of Energy Consumption and Egg Production in Poultry in Iran

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ABSTRACT: Energy use pattern analysis has been the subject of many researches in agricultural production systems; however livestock farming has not been thoroughly considered. Determining the impact of fuel and electricity on egg production is the purpose of the present study. To achieve this, firstly, data were collected by interviewing randomly selected poultry farmers and then the culled data were transformed into energy equivalents. Cobb-Douglas production function was chosen as the best suitable production function among the examined ones. The sensitivity analysis was carried out by estimating the MPP factor. Accordingly, fuel had negative effect on egg yield but electricity increase did not have any negative influence on poultry farms output. To manage better fuel use, employing state of the art technologies and strategies to optimize the energy consumption is strongly recommended.

Keywords: Egg production, poultry farms, energy, fuel, electricity, Cobb-Douglas

INTRODUCTION

The development of alternative energy resources has for some time been a central aim of energy policy around the world. Farm operations are continually increasing their use of electrical energy as farm size increases and agricultural production systems mechanized and supplanted by wood, coal and other fossil fuels, in recent years. Applying obsolete poultry equipment with the high amount of liquid fossil fuels is of greater concern to the studied area.

Frequent exploitation of non-renewable energy sources like fossil-based fuels and electricity in production systems are acting against sustainability. While energy resources are limited and depleting, the outlook of energy consumption needs optimizing decisions. The high growth in population of the communities, the consequent demand for increased yield and the necessity to provide sufficient food for the population growth has caused a rise in the share of agriculture in these resources usage. Therefore, fossil-based fuel energy resources should be conserved and managed, and careful investigations of non-renewable energy consumption analyses are needed. As a matter of fact, by increasing use of fossil-based fuel and electricity energy sources, the correspondent global problems will probably increase (Nabavi-Pelesaraei *et al.,* 2013; Ermis *et al.,* 2007). With regard to global impacts, greenhouse gases (GHG) emissions which contribute to global warming and increased level of air pollution adversely affect public and ecosystem health (Nguyen and Gheewala, 2008; Sabzevari *et al.,* 2015).

The apparent uses of unsustainable energy resources such as fossil fuels and electricity in modern poultry farming are mostly for implementing equipment, heating, cooling and lighting and many other applications. In Iran, considering to the high energy costs in comparison with low yield level and farmers' income, the amount of energy expenditure and its relation to egg production is befit of attention.

Considering various studies on energy use efficiency in livestock production systems (Ramirez *et al.,* 2006; Vinten-Johansen et al., 1990; Refsgaard *et al.,* 1998; Meul *et al.,* 2007); several studies have focused on fossil fuels energy consumption in different production systems (Bujak, 2009; Sardianou, 2008; Liu et al., 2010; Iriarte *et al.,* 2010). Technical and allocative efficiency investigation in poultry for egg production farms was studied by Ashagidigbi *et al.* (2011) in Nigeria. Similar study in the same zone as former study was done by Ojo (2003) and Yusuf and Malomo (2007). In another study carried out by Mohaddes (2011), production efficiency of egg production in Iran was analyzed. A transcendental frontier model was utilized in this study. Moreover, Heidari *et al.* (2011) determined the energy consumption per 1000 bird for the broiler production in Yazd province of Iran. Unfortunately, poultry farming and specifically the impacts of some energy inputs use per 1000 birds on egg yield has not been on center of attentions.

Hence, this study aimed to investigate empirically the impact of fossil-based fuels and electricity energy uses on egg yield, in a sample of Iranian poultry for egg farms.

MATERIALS AND METHODS

The study was carried out based on a survey done in Mazandaran province in Iran. This area plays an important role in the national production of egg representing approximately 26.5% of total output in 2009 production year. The whole country egg production was reported as 727200 tons in this year and this amount was 193122 tons for Mazandaran province (Anonymous, 2010). Energy coefficient equivalents derived from previous studies were applied to estimate the energy use pattern. The energy coefficient equivalents present the consumed energy during the production process and transportation (Table 1).

Energy consumption in agricultural systems is associated with all assumed inputs that take part in the production processes. The energy equivalent of electricity and fossil fuel inputs were estimated by multiplying the quantity of each input with its energy coefficient. For investigating the energy equivalent of egg the same method was utilized.

Table 1: Energy coefficient equivalents of inputs and outputs.

Items (unit)	**energy equivalent (MJ unit^{-1}(1000 birds)$^{-1}$)**	**References**
A. Inputs		
Fossil fuels		
Diesel (l)	47.8	(Kitani, 1999)
Kerosene (l)	36.7	(Kitani, 1999)
Electricity (kWh)	11.93	(Nabavi-Pelesaraei et al., 2014)
B. Output		
Egg (kg)	7.28	(Baum et al., 2009)

The Cobb-Douglas standardized and unstandardized coefficients were applied to the data by using a window-based statistical package program SPSS version 19.

The relation between electricity and fossil-based fuels energy inputs and output was investigated using a prior mathematical function relation. Cobb-Douglas production function was suggested as the appropriate functional form. Assuming that egg yield is a function of electricity and fossil fuels, for investigating the impact of each energy input (fossil fuels and electricity) on egg yield, the equation can be expanded in the following form (Sefeedpari *et al.*, 2012):

$$\ln Y_i = \sum_{j=1}^{n} \alpha_i \ln(X_{ij}) + e_i \quad (1)$$

where Y_i denotes the yield of the ith poultry farmer, X_{ij} the vector of inputs used in the production process, a_j represent coefficients of inputs which are estimated from the model and e_i is the error term. Assuming that the dependent variable Y was taken as egg yield (the main product of poultry farms) and was specified as a function of electricity and fossil fuels, Eq. (1) can be expanded to Eq. (2):

$$\ln Y_i = \alpha_1 \ln X_1 + \alpha_2 \ln X_2 \quad (2)$$

where X_1 is fuel energy, X_2 is electricity energy both in MJ (1000 birds)$^{-1}$ in 14 months.

Since the marginal product governs the law of production, the marginal physical productivity (MPP) technique, based on the response coefficients of the inputs, was used to determine the sensitivity of a particular energy input on production. The MPP of a fact indicates the change in the output with a unit change in the factor input in question, keeping all other factors constant at their geometric mean level. The MPP of the various inputs was computed using the a_j of the various energy inputs as:

$$MPP_{xj} = \frac{GM(Y)}{GM(X_j)} \times \alpha_j \quad (3)$$

where MPP_{xj} is marginal physical productivity of j^{th} input, aij regression coefficient of j^{th} input, GM(Y) geometric mean of egg yield and GM(X_{ij}) geometric mean of th input energy. A positive value of MPP of any factor indicates that production is increasing with an increase in input. A negative value of MPP of any factor input indicates that additional units of inputs are contributing negatively to production, i.e. less production with more input.

In validating the econometric models, autocorrelation was applied by using Durbin-Watson test (Singh *et al.* 2004). Return to scale was calculated by adding the elasticities (aij) derived in the form of regression coefficients in the Cobb-Douglas production function. Return to scale stresses the proportionate change in output due to an equi-proportionate change in all the inputs. If the sum is less than, equal to or greater than unity, the decreasing, constant or increasing return to scale is indicated, respectively (Singh *et al.*, 2004).

RESULTS AND DISCUSSION

Data collected from selected poultry farms of Iran were analyzed from the viewpoint of energy consumption of fossil based fuels and electricity. The total energy consumption of the two target factors was calculated to be 154594.4 MJ (1000 birds)$^{-1}$ in which fossil fuels were placed first due to its high consumption for heating production rooms and other utilizations in the farm. It was observed that farmers use electricity power in automatic feeding, automatic drinking and lighting equipment's. A key way to increase the productivity of chickens is artificial lighting. If the housing is lit in the cooler hours before sunrise or after sunset, the chickens are able to eat more (Heidari *et al.*, 2011). The egg yield was 20952.5 kg (1000 birds)$^{-1}$ in a production period of 14 months. Table 2 shows more detailed results of this study.

Table 2: Parameters quantity and energy equivalents of inputs and output parameters in a production period.

Item	Total amounts (unit(1000 birds)$^{-1}$)	Total energy equivalent (MJ(1000 birds)$^{-1}$)
A. Inputs		
Fossil fuels	3181.6	150376.5
Diesel (L)	3028	144738.4
Kerosene (L)	153.6	5638.1
Electricity (kWh)	353.5	4217.9
B. Output		
Egg (kg)	20952.2	152832

Table 3: Econometric estimation and sensitivity analysis of model 2.

Independent variables	Coefficient	t-ratio	MPP
Model 2: $ln\ Y_i = a_1\ ln(X_1) + a_2\ ln(X_2) + e_i$			
Fuel	-0.22	-1.39	-0.19
Electricity	0.135	0.85^{ns}	0.16
Durbin Watson (DW)	2.00		
R^2	0.96		
Return To Scale (RTS)	-0.08		

^{ns}: not significant

The results of this study will investigate the relationship between electricity and fossil-based fuels at poultry for egg production farms. Egg was assumed to be a function of electricity and fossil fuels energies. It is worth pointing out that elasticity and impact are exactly alike (Mohammadi and Omid, 2010). The autocorrelation test was performed by using Durbin-Watson test and calculated as 2 revealing that there was no autocorrelation at the 5% significance level in the estimated model. The R2 (coefficient of determination) was as 0.96 for this linear regression model. Estimated coefficients showed that electricity has a positive impact and fossil fuel is not contributed to egg yield. The negative impact of fuel energy indicated that any change in fuel energy consumption would decrease the egg yield. The MPP value of electricity showed that an additional use of 1 MJ (1000 birds)$^{-1}$ from machinery would result in an increase of 0.16 MJ (1000 birds)$^{-1}$ in egg yield. The results of econometric analysis are shown in Table 3.

The review of literature did not reveal any other study related to the present study to compare the results with. Hence, other production systems were considered. In the study done by Sefeedpari *et al.* (2012) on the effect of non-renewable energy sources (fossil-based fuels, electricity and machinery and equipment) in dairy farming, the relationship between fuel energy use and milk yield was assessed to be positive while electricity was contributed negatively.

CONCLUSION

The present study was designed to investigate the functional relationship between two main non-renewable energy sources including fossil fuel and electricity use on egg production of 40 selected poultry farms of Mazandaran province. To collect the required data and information, face to face questionnaire approach was implemented and farms were selected randomly. Information about inputs use, the yield amount and farmers' possible problems were gathered. Cobb-Douglas production function yielded the best results and therefore proposed for this study.

The total energy consuming for fuel and electricity providing was calculated to be 154594.4 MJ (1000 birds)$^{-1}$, in which fuel energy was more than electricity energy consumption. This is due to the fact that most poultry equipment uses fossil fuel to operate and heating of the poultry production rooms. Having better control on fuel use in these situations and on the other hand substituting obsolete equipment with the high-tech and efficient ones is recommended. Electricity was found to have positive impact on egg production while an increase in fuel use would result in egg yield decreasing. The R2 coefficient yielded well showing the dependent and independent variable selection has been suitable. With respect to the two former results it is suggested to develop the reasonable and more efficient production systems in poultry industry, improve energy auditing practices in livestock farming enterprises, make room insulated against transformation of heat and employ the novel and well-established techniques extensively. Besides, more alternative renewable energy sources such as solar energy, wind energy, biofuels etc should be introduced to farmers and equipment manufacturers. Educating farmers through extension programs would be helpful to achieve the goal of safer and cleaner products.

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