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Energy and economic analysis of broiler production under different farm sizes

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ABSTRACT

The aim of this study was to determine the amount of input-output energy used in broiler production and to make an economic analysis for broiler production in different sizes of farms in Iran. Data were collected from 70 producers, using face to face questionnaire method in Ardabil province. The surveyed farms were classified into three groups of small (less than 15000bird), medium (15000 to 30000 bird) and large farms (more than 30000 bird). The results indicated the total average energy input and output of 154and 27 GJ $(1000\text{bird})^{-1}$, respectively. The highest share in energy consumption belonged to fuel (61%) followed by feed (35%) and electricity (3%). Also, the results showed that large farms use the least amount of total energy per 1000bird; while, the highest energy output was obtained from medium farms. The share of direct, indirect, renewable and non-renewable energies was 64.62%, 35.38%, 35.28% and 64.72% respectively. The average energy use efficiency and productivity were calculated 0.18 and 0.02 kg MJ^{-1}, respectively. Cost analysis showed that total average cost of production was 3349 \$ $(1000\text{bird})^{-1}$. The benefit-cost ratio and productivity were 1.09 and 0.77 kg $\$^{-1}$, respectively. Mainly, the large farms had the highest energy ratio (0.21) and benefit to cost ratio (1.11); indicating a better management of energy and input consumptions in these farms.

Introduction

Poultry meat and eggs offer considerable potential for meeting human needs for dietary animal supply. FAO recommendation for daily protein consumption is put at 60 g per person out of which 35 g is expected to be of animal source (FAO, 2011). Poultry are acting efficiently in conversion of feed to egg and meat within a short period of time (Sefeedpari et al., 2012). Broiler is an important source of high quality proteins, minerals and vitamins to balance the human diet. Broiler is the third most consumed meat in the world, after beef and pork (Atilgan and Hayati, k., 2006).

The relation between agriculture and energy is very close. Agriculture itself is an energy user and energy supplier in the form of bio-energy (Mohammadi et al., 2008). Effective use of energy in agriculture is one of the key ways to reduce the energy consumption, since it helps to achieve increased production and productivity and contributes to the economy, profitability and competitiveness of agriculture sustainability in rural areas (Royan et al., 2012; Pahlavan et al., 2012). Energy analysis can be divided into two parts as direct and indirect energy. Direct energy is directly used at the farm and on fields for crops, but indirect energy is not directly consumed at the farm. However, both direct and indirect forms of energy are required for agricultural production in terms of its development and growth (Ozkan et al., 2004). On the other hand, a significant objective in agricultural production is to decrease costs and increase yield. In this respect, the energy budget is important. Energy budget is the numerical comparison of the relationship between input and output of a system or agricultural business in terms of energy units (Gezer et al., 2003).

In recent years, many researchers have investigated the energy use for agricultural Productions. Moreover, in some studies the effect of farm size on energy use efficiency of agricultural production was investigated. Yilmaz et al. (2005) examined the effect of farm size on energy use and input costs for cotton production in Turkey; from this study it was found that large farms were more successful in energy productivity, use efficiency and economic performance; also, it was concluded that energy management at farm level could be improved to give more efficient and economic use of energy. Cetin and Vardar (2008) and Pishgarkomle et al. (2011) investigated the energy consumption in small, medium and large farms of tomato and rice production, respectively; they concluded that large farms were more successful in terms of energy use and economic performance. Mousavi-avval et al. (2011) determined the amount of input–output energy used in canola production, to investigate the efficiency of energy consumption and to make an economic analysis of canola production in different farm sizes. The results revealed that the medium farms had the highest energy use efficiency and benefit to cost ratio; indicating a better management of energy and input consumptions in these farms.

The main objective of the present paper is to compare the energy use and economic efficiencies of broiler production in different farm sizes in Ardabil province of Iran. It also identifies operations where energy savings could be realized by changing applied practices in order to increase the energy ratio, and propose improvements to reduce energy consumption for broiler production.

Materials and methods

The study was carried out in broiler farms in Ardabil province of Iran. The province is located in the northwest of Iran, within 47° 15′ and 48° 56′ east longitude and 37° 09′ and 39° 42′ north latitude (Ministry of Jihad-e-Agriculture of Iran, 2012).

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Data were collected from the farmers by using a face-to-face questionnaire performed in September-October 2013 period. The sample size was calculated 70 farms, by using the Neyman method (Yamane, 1967). For the analysis of energy use in different farm sizes, the selected farms were classified into three categories as small (<15000 bird), medium (between 15000 and 30000 bird) and large farms (>30000 bird).

Input sources of broiler farm included chick, human labor, machinery, fuel, feed and electricity; while output sources were broiler and manure. Energy conversion factors were used to convert each input and output into energy equivalents. Energy equivalents were determined by multiplying the quantity per 1000 birds by their conversion factors (Table 1).

The energetic efficiency of the agricultural systems can be evaluated by the relation between energy inputs and outputs. Based on the energy equivalents of the inputs and outputs (Table 1), the energy ratio (energy use efficiency), energy productivity, the specific energy and net energy were calculated (Hatirli et al., 2006; Zanganeh et al., 2010):

$$\text{Energy use efficiency} = \frac{\text{Energy output}(\text{MJ}(1000\text{ bird})^{-1})}{\text{Energy input}(\text{MJ}(1000\text{ bird})^{-1})} \quad (1)$$

$$\text{Energy productivity} = \frac{\text{Yield (kg}(1000\text{ bird})^{-1})}{\text{Energy input}(\text{MJ}1000\text{ bird}^{-1})} \quad (2)$$

$$\text{Specific energy} = \frac{\text{Energy output}(\text{MJ ha}^{-1})}{\text{Yield (kg}(1000\text{ bird})^{-1})} \quad (3)$$

$$\text{Net energy} = \text{Energy output}(\text{MJ}(1000\text{ bird})^{-1}) - \text{Energy input}(\text{MJ}(1000\text{ bird})^{-1}) \quad (4)$$

The total energy input is also classified into direct and indirect and renewable and non-renewable forms. Direct energy (DE) includes human labor, diesel fuel and electricity, while indirect energy (IDE) covers energy embodied in chick, machinery and feed used in the broiler farms production. Renewable energy (RE) includes of chick, human labor and feed, whereas non-renewable energy (NRE) consists diesel fuel, machinery and electricity. Renewable energy used to describe energy sources that are replenished by natural processes on a sufficiently rapid time-scale. So they can be used by humans more or less indefinitely, provided the quantity taken per unit of time is not too great. On the other hand non-renewable energy used to describe energy sources that exist in a limited amount on Earth (Pishgar-komleh et al., 2011).

In the last part of this study the economic analysis of broiler production in different farm sizes was investigated. The total cost of broiler production consists of fixed and variable costs. The fixed costs were the amount of renting cost for one year. The variable costs were costs of human labor and the cost of used materials such as chick, fuel, feed, electricity, drug and vaccine. All data costs were calculated per 1000 bird and used to estimate the economic indices. Net profit, gross profit and benefit to cost ratio was calculated. The net return was calculated by subtracting the total cost of production from the gross value of production per hectare. The gross return was calculated by subtracting the variable cost of production. The benefit-cost ratio was calculated by dividing the gross value of production by the total cost of production per 1000 bird. All economic parameters can be expressed by Eqs. (5)-(9) (Pishgar-komoleh et al., 2012; Salehi et al., 2014):

$$\text{Total production value} = \text{Broiler yield (kg}(1000\text{ bird})^{-1}) \times \text{Broiler price } (\$\text{ kg}^{-1}) \quad (5)$$

$$\text{Gross return} = \text{Total production value } (\$\ (1000\text{ bird})^{-1}) - \text{Variable production cost } (\$\ (1000\text{ bird})^{-1}) \quad (6)$$

$$\text{Net return} = \text{Total production value } (\$\ (1000\text{ bird})^{-1}) - \text{Total production cost } (\$\ (1000\text{ bird})^{-1}) \quad (7)$$

$$\text{Benefit} - \text{cost ratio} = \frac{\text{Total production value } (\$\ (1000\text{ bird})^{-1})}{\text{Total production cost } (\$\ (1000\text{ bird})^{-1})} \quad (8)$$

$$\text{Productivity} = \frac{\text{Broiler yield (kg}(1000\text{ bird})^{-1})}{\text{Total production cost } (\$\ (1000\text{ bird})^{-1})} \quad (9)$$

All estimations were carried out using the Microsoft Excel spreadsheet and SPSS 17.0 software programs.

Results and Discussion

Analysis of input-output energy use in broiler production

The amount of inputs and outputs for broiler production in different farm sizes are presented in Table 2. The results indicated the average value of 5.56 and 6642.90 kg $(1000\text{bird})^{-1}$ for Machinery and Feed inputs. The average fuel consumption was 1893.01 L $(1000\text{bird})^{-1}$ in the broiler production. The average human labor and Electricity use were 74.11 h $(1000\text{bird})^{-1}$ and 6642.90 kWh $(1000\text{bird})^{-1}$. As it can be seen in Table 2 there was difference between the input consumption in three group of farm size except in chick input. The average outputs value was determined as 2596.90 and 2296.33 kg $(1000\text{bird})^{-1}$ for broiler and Manure, respectively from which the highest one belonged to medium farms followed by large and small farms.

The average energy consumption of inputs and outputs for broiler production are presented in table 3. Total average energy input and output were calculated 154283.87 and 27447.26 MJ $(1000\text{bird})^{-1}$. The highest energy use in broiler production belonged to fuel energy input which accounted about 61% of total energy consumption. Fuel input plays an important role in total energy consumption for broiler production. It should be noted that fuel was used for the heating production rooms. Old equipment are the reasons for high fuel energy consumption in broiler production in Iran. Applying new equipment with more energy efficiency decrease the amount of energy usage. Fuel energy was followed by the feed energy with the share of 35% of total energy inputs. The share of electricity energy consumption was calculated about 3% of all energy inputs in broiler production. As shown in Table 3, human labor (0.1%) was the least demanding energy input among the whole specified inputs in broiler production and machinery was accounted for 0.2% of total input energy. Similar results were reported by Heidari et al., (2011) that highest energy factors were fuel (59.20%), feed (31.71%) and electricity (8.61%) in broiler production in Yazd province in Iran.

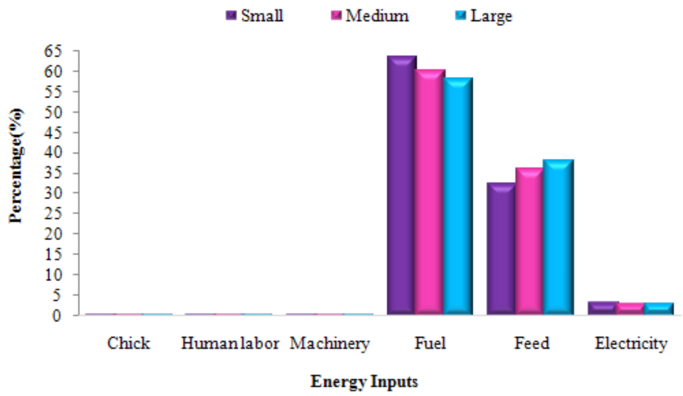

Fig. 1. Distribution of energy inputs in different farm sizes of broiler production.

The comparison of energy inputs consumption based on farm size showed that farmers with more than 30000 bird production use the least amount of energies. The results that showed medium and large farms (15000-30000 and more than 30000 bird) had better use of energy management in broiler production. The percentage associated of energy inputs in different farm sizes of broiler production are depicted in Fig. 1. As it is seen, in all the three groups of farm sizes the fuel, feed and electricity were the main energy consuming inputs, respectively. Moreover, the contributions of human labor, machinery and chick energies from total energy input were found to be relatively low.

To evaluate three group of farm size it is necessary to calculate and compare the energy use efficiency index. Energy indices including energy use efficiency, energy productivity, specific energy and net energy are shown in Table 4. Energy ratio (energy use efficiency) shows the efficient use of energy in crop production. The results indicated that average energy use efficiency was estimated 0.18 and showing the inefficiency use of energy in the broiler production of Ardabil province. Obviously, the achieving of high rate for energy use efficiency can be help to obtain the better production system in energy use point of view. It is concluded that energy use efficiency can be increased by raising the meat yield and or by decreasing energy input consumption. Sefeedpari (2012) reported that the energy ratio of dairy farms in Tehran province was 0.26. Also, several authors have been reported the energy use efficiency for different crops such as 0.15, 0.38 and 0.028 for strawberry, cucumber and button mushroom production, respectively (Banaeian et al., 2011; Monjezi et al., 2011; Salehi et al., 2014). As farm sizes increase, energy ratio increases accordingly, the highest value of energy ratio belonged to large farms size in comparison with small and medium farms size because of better management and using less energy input and producing more energy output (more yield) are two methods to reach higher energy ratio value.

The average energy productivity of broiler production was 0.02 kg MJ-1. This means that using 1 MJ of energy would result in 0.02 unit outputs. The specific energy and net energy were calculated as 59.56 MJ kg^{-1} and -126836.61 MJ $(1000\ bird)^{-1}$, respectively. Net energy is negative. Therefore, it means that energy is being lost in broiler production. Similar results have been reported 0.12 kg MJ^{-1}, 9.48 MJ kg^{-1} and -55217.3 MJ cow^{-1} for the energy productivity, specific energy and net energy of dairy farm, respectively (Sefeedpari, 2012). As seen in Table 3, large farms had better energy indices) energy ratio, energy productivity, specific energy and net energy) that it can be referred to the better management of large scale farms.

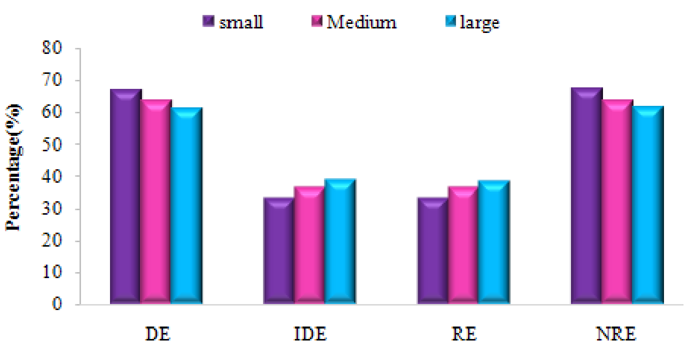

Fig 2. Forms of total energy in different farm sizes of broiler production

The distribution of inputs used in the production of broiler according to the direct, indirect, renewable and non-renewable energy forms for all of farm groups are given in Table 5. Percentages of these energy forms are illustrated in Fig. 2. The total consumed energy input could be classified as direct energy (64.62%), and indirect energy (35.38%) or renewable energy (35.28%) and nonrenewable energy (64.72%). The results revealed that, in all of the farm groups, the rate of direct energy was greater than that of indirect energy and the contribution of non-renewable energy forms was higher than that of renewable energy consumption in broiler production and among the DE and NRE sources fuel and electricity were accounted as the most influential factors, so, considerable attention on energy management should be drown.

Economic analysis of broiler production

In order to evaluate the seed corn production from economic point of view, economic analysis was performed and the results are presented in Table 6. As it is represented, variable and fixed cost were 3202.45 \$ $(1000bird)^{-1}$ and 147.12 \$ $(1000bird)^{-1}$ with share of 95% and 5% of total cost, respectively. By multiplying sale price by broiler yield, the total production value calculated (3642.94 \$ $(1000bird)^{-1}$). Total cost of production was 3349.57 \$ (1000bird)-1 and 1.29 \$ kg^{-1}. Gross and net return were 440.49 \$ $(1000bird)^{-1}$ and 293.37 \$ $(1000bird)^{-1}$, respectively. The benefit to cost ratio of broiler production was calculated to be 1.09 that was lower than Heidari et al. (2011) research results of benefit-cost ratio (1.38). The economic research in other crops revealed the benefit to cost ratio value of 1.10 (Mandal et al., 2002), 1.03 (Esengun et al., 2007), 1.17 (Erdal et al., 2007) and 1.15 (Salehi et al., 2014) for soybean, stake-tomato, sugar beet, and button mushroom, respectively. At the end of economic analysis of broiler production, the economic productivity was calculated 0.77 \$ kg^{-1}. The effect of broiler farm size on the benefit to cost ratio revealed that large farms (>30000 bird) had better values because of better management in consumption of energy inputs.

Conclusions

This study analyzed the input and output energy and benefit to cost ratio of broiler production in small, medium and large. The results revealed that total energy consumption of broiler production was calculated to be 154283 MJ $(1000bird)^{-1}$ in which Fuel (61%) was the largest energy input, followed by feed (35%). The least energy consumption belongs to labor with share of 0.1%. The comparison of energy inputs consumption based on farm size showed that large farms use the least amount of total energy. Total energy output was 27447 MJ $(1000bird)^{-1}$ where medium farms had the highest energy output. Energy use efficiency, energy productivity, specific energy and net energy were found to be 0.18, 0.02 kg MJ^{-1}, 59 MJ kg^{-1} and -126836 $MJ(1000bird)^{-1}$, respectively. The analysis of three groups of farms indicated that the best results of energy indices are found in large farms of broiler production. The share of direct and indirect energy of total energy was 65% and 35%, respectively. The portion of renewable energy was 35% while the renewable form was 65%. The results revealed that forms of energy consumption in large broiler farms were the least.

The average value of total cost of production, gross return, net return, benefit-cost ratio and productivity of rice production calculated to be 3349 \$ $(1000bird)^{-1}$, 440.49 \$ $(1000bird)^{-1}$, 293.37 \$ $(1000bird)^{-1}$, 1.09 and 0.77 kg $\$^{-1}$ respectively. Feed costs are, as a rule, the greatest expenditure of a broiler farm. Therefore, with management in consumption of input such as feed, the benefit-cost ratio in broiler production will increase. Mainly, the effect of broiler farm size studied and the results revealed large farms (<30000bird) have better efficiency for broiler energy and economic analysis in the research area. Energy use in broiler production is not efficient and detrimental to the environment due to excessive use of inputs.

Table 1. Energy coefficients of inputs and outputs in broiler production.

Items	Unit	Energy equivalent (MJ unit^{-1})	Reference
A. Inputs			
1. Chick	kg	10.33	(Heidari et al., 2011)
2. Human labor	h	1.96	(Nabavi-Pelesaraei., 2014)
3. Machinery			
(a) Polyethylene	kg	46.3	(Kittle, 1993)
(b) Galvanized iron	kg	38	(Sefeedpari et al., 2013)
(c) Steel	kg	62.7	(Chauhan et al., 2006)
(d) Electric motor	kg	64.8	(Chauhan et al., 2006)
4. Fuel	L	47.8	(Kitani, 1999)
5. Feed			
(a) Maize	kg	7.9	(Atilgan and Hyati, 2006)
(a) Soybean meal	kg	12.06	(Atilgan and Hyati, 2006)
(a) Dicalcium phosphate	kg	10	(Alrwis and Francis, 2003)
(a) Minerals and vitamins	kg	1.59	(Sainz,2003)
(a) Fatty acid	kg	9	(Heidari et al., 2011)
6. Electricity	kWh	11.93	(Ozkan et al., 2004)
B. Outputs			
1. Broiler	kg	10.33	(Heidari et al., 2011)
2. Manure	kg	0.3	(Kizilaslan, 2009)

Table 2. Amounts of inputs and outputs in different farm sizes of broiler production.

Items	Units	Farm size groups (1000 bird)		
		Small (<15000)	Medium (15000-30000)	Large (>30000)
A: Inputs				
1. Chick	kg	47.50	47.50	47.50
2. Human labor	h	82.94	78.25	61.15
3. Machinery	kg	6.32	5.68	4.70
4. Fuel	L	2161.07	1887.54	1630.43
5. Feed	kg	6678.10	6809.16	6441.44
6. Electricity	kWh	440.41	370.09	338.19
B: Outputs				
1. Broiler	kg	2544.71	2630.64	2615.35
2. Manure	kg	2224.21	2360.89	2303.91

Table 3. Amounts of energy inputs and outputs in broiler production (MJ (1000 bird)$^{-1}$).

Items	Farm size groups			Total energy	Percentage (%)
	Small (<15000)	Medium (15000-30000)	Large (>30000)		
A: Inputs					
1. Chick	490.68	490.68	490.68	490.68	0.32
2. Human labor	162.56	153.36	119.85	150.12	0.10
3. Machinery	334.81	300.56	249.12	304.22	0.20
4. Fuel	105136.17	91828.97	79320.62	94851.69	61.48
5. Feed	53825.45	54881.81	51917.99	53793.98	34.87
6. Electricity	5254.14	4415.17	4034.57	4693.17	3.04
Total energy inputs	165203.81	152070.55	136132.83	154283.87	100
B: Outputs					
1. Broiler	26286.82	27174.50	27016.59	26760.23	97.50
2. Manure	667.26	708.27	691.17	687.03	2.50
Total energy outputs	26954.09	27882.76	27707.76	27447.26	100

Table 4. Energy indices in broiler production

Items	Unit	Farm size groups			Average
		Small (<15000)	Medium (15000-30000)	Large (>30000)	
Energy input	$MJ(1000bird)^{-1}$	165203.81	152070.55	136132.83	154283.87
Energy output	$MJ(1000bird)^{-1}$	26954.09	27882.76	27707.76	27447.26
Energy use efficiency	-	0.17	0.19	0.21	0.18
Energy productivity	$kg(MJ)^{-1}$	0.02	0.02	0.02	0.02
Specific energy	$MJ(kg)^{-1}$	65.29	58.33	52.18	59.56
Net energy	$MJ(1000bird)^{-1}$	-138249.72	-124187.79	-108425.07	-126836.61

Table 5. Total energy input in the form of direct (DE), indirect (IDE), renewable (RE) and non-renewable (NRE) for broiler production.

Items	Unit	Farm size groups			Average	(%)
		Small (<15000)	Medium (15000-30000)	Large (>30000)		
DE[a]	$MJ(1000bird)^{-1}$	110552.87	96397.51	83475.04	99694.99	64.62
IDE[b]	$MJ(1000bird)^{-1}$	54650.94	55673.04	52657.79	54588.87	35.38
RE[c]	$MJ(1000bird)^{-1}$	54478.69	55525.85	52528.52	54434.78	35.28
NRE[d]	$MJ(1000bird)^{-1}$	110725.13	96544.71	83604.31	99849.09	64.72
Energy input	$MJ(1000bird)^{-1}$	165203.81	152070.55	136132.83	154283.87	-

[a] Includes human labor, fuel, electricity.

[b] Includes chick, machinery, feed.

[c] Includes labor, chick, feed.

[d] Includes machinery, fuel, electricity.

Table 6. Economic analysis of broiler production.

Items	Unit	Farm size groups			Average
		Small (<15000)	Medium (15000-30000)	Large (>30000)	
Yield	kg $(1000bird)^{-1}$	2544.71	2630.64	2615.35	2590.54
Scale price	$ $(kg)^{-1}$	1.41	1.41	1.41	1.41
Total Production value	$ $(1000bird)^{-1}$	3578.49	3699.34	3677.84	3642.94
Variable cost of production	$ $(1000bird)^{-1}$	3155.40	3286.98	3155.66	3202.45
Fixed cost of production	$ $(1000bird)^{-1}$	142.43	146.78	155.24	147.12
Total cost of production	$ $(1000bird)^{-1}$	3297.83	3433.76	3310.90	3349.57
Total cost of production	$ kg^{-1}	1.30	1.31	1.27	1.29
Gross return	$ $(1000bird)^{-1}$	423.09	412.36	522.18	440.49
Net return	$ $(1000bird)^{-1}$	280.66	265.58	366.94	293.37
Benefit to cost ration	-	1.08	1.08	1.11	1.09
Productivity	kg $\$^{-1}$	0.77	0.77	0.79	0.77

Optimal consumptions of diesel fuel and feed would be useful not only in reducing negative effects to environment and human health, but maintaining sustainability and decreasing production costs. At the end of this study, recommended that with teaching farmers and increasing level production, the high energy consumption of fuel, feed and electricity energy will be controlled, hence this act leads to improvement in energy indices in broiler production. Therefore, Energy management should be considered as an important issue in terms of sustainable, efficient and economic use of energy.

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