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Effect of different housing systems (cages versus floor) on energy efficiency analysis of meat type Japanese quails

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ABSTRACT

The aim of the present study was to make an energy efficiency analysis of Japanese quails reared under cage and floor conditions in Bingöl province of Turkey. Japanese quails (1,000) were utilized for trials and measurements. Energy use efficiency, energy productivity, specific energy and net energy calculated under cage system was 0.11; 0.01 kg/MJ; 76.18 MJ/ kg and –12868.38 MJ/ (1,000 bird), respectively; and 0.09; 0.01 kg/MJ; 89.79 MJ/ kg and –13488.06 MJ/ (1,000 bird), respectively, under floor conditions. The total direct energy input was 17.11 and 16.61%, and indirect 82.29 and 83.39% under cage and floor conditions, respectively. The total renewable energy input was 79.65 and 83.33%, non-renewable as 20.35 and 16.67% under cage and floor conditions, respectively.

Hence, the Japanese quail production under cage and floor conditions is not a viable activity in terms of energy usage. Modern and well established scientific practices should be used to obtain more energy efficiency and maximum economic benefits without overstressing the energy consumption. Further, using solar energy to warm up poultry house may be useful in increasing the energy usage ratio. Since, feed had the highest rate of total energy input, it may be reduced by keeping the chicks stress-free.

Key words: Energy use efficiency, Japanese quail, Specific energy

Efficient use of energy is one of the principal requirements of sustainable agriculture. However, intensive use of energy causes problems which are threatening for public health and environment (Esengun *et al*. 2007). Efficient use of energy in agriculture will minimize environmental problems, prevent destruction of natural resources, and promote sustainable agriculture as an economical production system (Erdal *et al*. 2007). Energy efficiency (energy input-output analysis) is closely associated with economic (profitability) and ecological aspects of the chosen farming systems. Energy efficiency and energy balance can be accepted as a vital tool to determine the environmental impacts of farming systems. Determination of the energy efficiency makes it possible to compare different farming systems in environment friendly production as well as sustainability of non-renewable natural resources (Celik *et al*. 2010).

Poultry breeding has became the most extensively developing branch of animal husbandry in the last 15 years. Along with the increase in egg and meat production, attempts at assortment diversification were made. These trends are particularly apparent in meat production. Ostrich, pheasant or quail meat is mostly available in bigger retail stores (Genchev *et al*. 2008). Quail meat is still mainly regarded as a food delicacy or a kind of food for special occasions; even though, in some countries quail meat represents an interesting niche business. In terms of its basic composition, it is quite similar to broiler meat, and for this reason quail meat can easily satisfy the consumers' requirement about healthy food with low cholesterol content and high polyunsaturated fatty acids (Tavaniello 2014). Heidari *et al*. (2011) reported that the major sources of protein in developing countries are beef, goat, mutton and poultry meats while other sources termed miscellaneous are egg and milk which have a bulk share of animal protein required by man. It is necessary to note that adequate consumption of meat is an indication of social and economic welfare (Ikeme 1990).

Researches were made on energy usage activities of broiler production (Atilgan and Koknaroglu 2006, Heidari *et al*. 2011, Qotbi 2011, Najafi *et al*. 2012, Nabavi-Pelesaraei *et al*. 2013, Sefat *et al*. 2014), egg production (Ojo 2003, Binuomote *et al*. 2008, Sefeedpari *et al*. 2012), lamb production (Koknaroglu *et al*. 2008) and beef cattle production (Demircan and Koknaroglu 2007). Since, there is no published report on the energy efficiency analysis of Japanese quail production in Turkey so far; therefore, the present study was aimed to determine the energy efficiency of Japanese quails under different housing systems (cages versus floor).

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MATERIAL AND METHODS

The study was conducted in Bingöl/Turkey. Two trials (49 days in total) were conducted utilizing 75-bird capacity cage and floor poultry house, respectively, located at Bingöl University farm in summer 2014.

Three replications were done in this study. Floor area is 3.60 m × 2 m (7.2 square meters). Quails were meat type birds. Among energy inputs; chick energy, human labour energy, equipment energy, feed energy, electricity energy, water energy and transportation energy values were taken into consideration. Equipments consisted of ventilating fans, lamps, heaters and cages. Japanese quails meat energy values were taken into consideration as energy output.

The energy equivalents of inputs and outputs in Japanese quail production taken as energy values are given in Table 1. Energy balance calculations were made to determine the productivity level. The units shown in Table 1 were used to find out the values of inputs which were then multiplied by the energy equivalent coefficient. The energy equivalent coefficients were determined by the help of previous energy analysis studies (shown as references in Table 1). By adding energy equivalents to all inputs in MJ unit, the total energy equivalent was worked out.

Table 1. Energy equivalents of inputs and outputs in Japanese quail production

Inputs and outputs	Unit	Energy equivalent coefficient	References
Inputs	Unit	Values (MJ/ unit)	
Chick	kg	8.04	Tavaniello (2014)
Human	h	1.96	Mani *et al.* (2007) Karaagac *et al.* (2011)
Equipment (Plastic)	kg	90	Canakci *et al.* (2006)
Equipment (Iron)	kg	27.73	Canakci *et al.* (2006)
Starter	kg	12.97	Calculated (Table 2)
Finisher	kg	13.60	Calculated (Table 2)
Electricity	kWh	3.60	Ozkan *et al.* 2004
Water	ton	0.63	Yaldiz *et al.* 1993
Transportation	MJ (tonne/ km)	9.22	Acaroglu (2004)
		Values (MJ/ unit)	
Output	Unit		
Bird	kg	8.04	Tavaniello (2014)

Values of inputs were calculated per 1,000 birds, and then the outcome multiplied by the equivalence of these inputs. The energy use efficiency, energy productivity, net energy and specific energy were calculated by using the following formulae, as reported by Yilmaz *et al*. (2010).

Energy use efficiency = Energy output (MJ/1,000 bird) / Energy input (MJ/ 1,000 bird)

Energy productivity = Yield (kg/ 1,000 bird) / Energy input (MJ/ 1,000 bird)

Specific energy = Energy input (MJ/ 1,000 bird) / Yield (kg/ 1,000 bird)

Net energy = Energy output (MJ/ 1,000 bird) - Energy input (MJ/1,000 bird).

The input energy was also classified into direct and indirect; renewable and non-renewable forms (Yilmaz *et al*. 2005). The total input and output energy values were calculated in MJ unit.

RESULTS AND DISCUSSION

This research was conducted to determine the energy efficiency calculations and comparison of energy use in cage and floor rearing. The values regarding the input-output values under cage and floor rearing are given in Tables 2, 3. The average amount of Japanese quail meat per 1,000 birds under cage and floor conditions was 188.85 kg and 164.99 kg, respectively. Feed energy, electricity energy and equipment energy were used as the highest input. The results revealed that the first, second and third highest energy inputs in Japanese quail production were 77.04 and 80.79% feed energy, 15.80 and 15.34% electricity energy and 4.54 and 1.31% equipment energy under cage and floor conditions, respectively.

Table 2. Energy input-output analysis in Japanese quail production under cage system

Inputs	Unit	Quantity per unit (1,000 bird)	Total energy value MJ/ (1,000 bird)	Ratio (%)
Chick	kg	23.21	186.61	1.30
Human labour	h	94.99	186.18	1.29
Equipment	kg	7.26	653.33	4.54
Feed				
Starter	kg	117.20	1520.08	10.57
Finisher	kg	703.20	9563.52	66.47
Electricity	kWh	631.33	2272.78	15.80
Water	ton	3.93	2.48	0.02
Transportation	MJ (tonne/ km)	0.19	1.75	0.01
Total inputs			14,386.73	100.00
Outputs				
Meat	kg	188.85	1,518.35	100.00
Total outputs			1,518.35	100.00
Energy ratio			0.11	

The results of the present study are in agreement with Atilgan and Koknaroglu (2006) and Sefeedpari *et al*. (2012) who reported that in broiler study and egg study, respectively, feed energy was the biggest energy input. Similarly, Sefeedpari *et al*. (2013) concluded that in poultry farm production study, the biggest input was feed energy. Heidari *et al*. (2011), Nabavi-Pelesarai *et al*. (2013) and Almasi *et al*. (2014) concluded that the second energy input in broiler study was feed energy. Similarly, Heidari *et al*. (2011), Najafi *et al*. (2012) and Nabavi-Pelesarai *et al*. (2013) reported electricity energy as the third highest energy input in broiler study.

The human labour energy input was 186.18 MJ/ (1,000 bird) under both cage and floor conditions. Human labour

Table 3. Energy input-output analysis in Japanese quail production under floor system

Inputs	Unit	Quantity per unit (1,000 bird)	Total energy value MJ/ (1,000 bird)	Ratio (%)
Chick	kg	23.51	189.02	1.28
Human labour	h	94.99	186.18	1.26
Equipment			194.13	1.31
Plastic	kg	1.04	93.60	0.68
Iron	kg	3.63	100.53	0.63
Feed		885.90	11,968.51	80.79
Starter	kg	126.55	1,641.35	11.08
Finisher	kg	759.35	10,327.16	69.71
Electricity	kWh	631.33	2,272.78	15.34
Water	ton	3.93	2.48	0.02
Transportation	MJ	0.16	1.47	0.01
Total inputs	(tonne/ km)		14814.57	100.00
Inputs				
Meat	kg	164.99	1,326.51	100.00
Total outputs			1,326.51	100.00
Energy ratio			0.09	

energy was used for farm operations such as feed application, etc. Equipment energy input calculated under cage and floor conditions was 653.33 MJ/ (1,000 bird) and 194.13 MJ /(1,000 bird), respectively. Equipment energy was used for farm operations like cage, fan, wiry, etc. Electricity energy in Japanese quail production was 2272.78 MJ/ (1,000 bird) under both and used for chick heating, lighting and ventilating.

Energy input-output and efficiency calculations in Japanese quail production are given in Table 4. Sefat *et al*. (2014) calculated the energy ratio in broiler chicken as 0.15. Similarly, Nabavi-Pelesaraei *et al*. (2013) reported energy use efficiency, energy productivity and specific energy in broiler study as 0.11, 0.01 kg/MJ and 84.53 MJ/kg, respectively. Sefat *et al*. (2014) calculated, energy use efficiency, energy productivity, specific energy and net energy in broiler study as 0.15, 0.01 kg/ MJ, 76.59 MJ/kg, and 189,769 MJ/(1,000 bird), respectively. Heidari *et al*. (2011) reported 0.15, 0.01 kg/ MJ and 71.95 MJ/kg and Almasi *et al*. (2014) 0.15, 0.01 kg/MJ and 76.28 MJ/kg as

Table 4. Energy input-output and efficiency calculations in Japanese quail production

Calculations	Unit	Cage production	Floor production
Meat	kg/ (1,000 birds)	188.85	164.99
Energy input	MJ/ (1,000 birds)	14386.73	14814.57
Energy output	MJ/ (1,000 birds)	1518.35	1326.51
Energy use efficiency		0.11	0.09
Energy productivity	kg/ MJ	0.01	0.01
Specific energy	MJ kg/ (1,000 bird)	76.18	89.79
Net energy (-)	MJ/ (1,000 bird)	12,868.38	13,488.06

Table 5. Energy input in the form of direct and indirect; renewable and non-renewable energy in Japanese quail production

Type of energy	Cage		Floor	
	Energy input MJ/ (1,000 bird)	Ratio (%)	Energy input MJ/ (1,000 bird)	Ratio (%)
Direct energy [a]	2461.44	17.11	2,461.44	16.61
Indirect energy [b]	11,925.29	82.89	12,353.13	83.39
Total	14,386.73	100.00	14,814.57	100.00
Renewable energy [c]	11,458.87	79.65	12,346.19	83.33
Non-renewable energy [d]	2,927.86	20.35	2,468.38	16.67
Total	14,386.73	100.00	14,814.57	100.00

[a] Includes human labour, electricity and water; [b] Includes chick, equipment, transportation, and feed; [c] Includes human labour, chick, feed and water; [d] Includes equipment, transportation and electricity.

energy use efficiency, energy productivity and specific energy, respectively, in a broiler study. Najafi *et al*. (2008) calculated energy use efficiency in broiler study as 0.25.

The distribution of inputs used in the production of Japanese quails in terms of direct energy, indirect energy, renewable energy and non-renewable energy is given in Table 5. The total energy input consumed can be classified as 17.11 and 16.61% direct; 82.29 and 83.39% indirect in Japanese quail production under cage and floor conditions respectively. Likewise, the respective total energy input consumed could be classified as 79.65 and 83.33% renewable; 20.35 and 16.67% non-renewable.

Energy management should be considered as an important field in terms of an efficient, sustainable and economical use of energy (Tipi *et al*. 2009). Modern and well established scientific practices should be used to obtain more energy efficiency and maximum economic benefits from poultry farming. The importance of energy consumption cannot be overstressed. The desire to save energy cannot be realized unless accurate records of energy consumption are kept (Heidari *et al*. 2011).

Optimal energy consumption in agriculture is reflected in two ways (a) increase productivity through existing levels of energy inputs; or (b) conserve energy. In conclusion, the Japanese quail production under cage and floor conditions is not a viable activity in terms of energy usage.

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