Determining the energy usage efficiency and economic analysis of broiler chickens raised under organic conditions

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ABSTRACT

This study was conducted to determine the energy usage efficiency of broiler chickens raised under organic conditions. To accomplish this goal, the energy input-output of every 1,000 broiler chickens raised in organic conditions was calculated. Efficiency of energy use, energy productivity, specific and net energy for broiler chickens were calculated as 0.30, 0.03 kg/MJ, 35.36 MJ/kg and −75557.96 MJ/1,000 bird, respectively. If we were to categorize the energy input total that was consumed, 9.57% was direct, 90.43% was indirect, 89.57% was renewable and 10.43% was non-renewable. In this sense, organic broiler production cannot be deemed as economically viable considering the energy usage. Feed energy was observed as the highest rate of total energy input. To reduce feed energy input, chicks should not be kept under stress and total output energy should be increased by increasing bird production number. Benefit-cost ratio was determined as 2.41.

Key words: Benefit-cost ratio, Broiler chickens, Energy productivity, Energy usage efficiency, Specific energy

The universal food system will experience an unprecedented concurrence of pressures over the next 40 years. Universal population size will be nearly 8 billion by 2030, and likely to be over 9 billion by 2050, people are likely to be wealthier, achieving a demand for a more different and quality diet taking extra resources to be grown (Asadollahpour *et al*. 2013). Energy efficiency (energy analysis) is closely associated with economic and ecological outlook of the chosen farming systems (Celik *et al*. 2010).

Energy use in agriculture has developed in response to rising populations, limited supply of arable land and desire for a rising standard of living. In all societies, these factors have encouraged an increase in energy inputs to maximize yields, minimize labour-intensive practices or both (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).

The prevailing properties of this production system is defined in regulations (Council Regulation 1999), additional care for animal comfort (ensuring better stocking intensity, perches, free-range fields), avoiding growth promoters

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(80% of feed must conform to organic norms), and no artificial fertilizers or pesticides should be used (Castellini *et al.* 2002). Many researches were conducted on energy usage activities on broiler production (Atilgan and Koknaroglu 2006; Heidari *et al.* 2011; Qotbi *et al*. 2011; Najafi *et al*. 2012; Nabavi-Pelesaraei *et al.* 2013; Sefat *et al.* 2014). The present study was aimed to determine the energy usage efficiency on broiler chickens raised in organic conditions in Bingöl, Turkey.

MATERIALS AND METHODS

The study was conducted to define the energy input-output efficiency of 180 birds in a 10 week period (70 days) in summer raised at a poultry house in Bingöl, Turkey. As energy inputs, chick energy, human labour energy, equipment energy, feed energy, electricity energy, water energy and transportation energy values were taken into consideration. Broiler meat energy values and manure are indicated as energy outputs in Table 1, where broiler data were provided and the energy equivalence of inputs and outputs were determined as the energy values. Calculations of energy balance were employed to find out the productivity levels of broiler chickens.

The data in Table 1 were employed to find out the input values of the raised broiler chickens. After calculating the input amounts, these input data and energy equivalent coefficient were multiplied. For the purposes of calculating the total energy equivalent, energy responses of all inputs in MJ unit were added. Energy usage efficiency, energy productivity, specific and net energy were determined by handling the following formulas (Yilmaz *et al.* 2010):

Energy use efficiency = Energy output (MJ/1000 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).

Energy equivalences in Table 1 were put to use to calculate the input quantities. Quantities of inputs were calculated for 1,000 birds and then were multiplied by the equivalence of these inputs. Previous studies were used to calculate the energy equivalence coefficients. The results were tabulated by taking the inputs into account, after the data were analyzed. Diet content of the trial are given in Table 2. Examining the values of the raised broiler chickens' input-output, as well as the relevant calculations are given in Table 3. Energy efficiency calculations of the raised broiler chickens are provided in Table 4. In addition, input energy categorized for broiler chickens are given in Table 5. Economic analyses of broiler chickens production are provided in Table 6.

RESULTS AND DISCUSSION

The energy input-output analysis are given in Table 1 and ratios (%) of inputs distributions are presented in Fig. 1. Composition of the diets used in trial are given in Table 2. During the trials, the average quantity of broiler per 1,000 birds was calculated as 3,045.36 kg. In broiler chickens, feed energy, electricity energy and equipment energy were the highest inputs. The highest ranked energy inputs calculated for broiler were feed energy (88.85%), electricity energy (9.27%) and equipment energy (1.12%). The energy inputs in broiler chickens were 95,694.92 MJ/ 1,000 bird (88.85%) for feed energy, 9,983.16 MJ/1,000 bird (9.27%) for electricity energy, 1,203.06 MJ/1,000 bird (1.12%) for equipment energy, 444.19 MJ/1,000 bird (0.41%) for chick energy, 321.20 MJ/1,000 bird (0.30) for human labour energy, 49.22 MJ/1,000 bird (0.05%) for transportation energy and 9.27 MJ/1,000 bird (0.01) for water energy (Table 3). Within the scope of this research, feed energy had the biggest share by 88.85%. Human labour was used for farm studies such as feed application, keeping etc. was 321.20 MJ/1,000 bird in broiler chickens. Equipment energy is used for farm operations such as fan, water tank, feed racks, water case, pipe, wiry etc. This value was calculated as 1,203.06 MJ/1,000 bird.
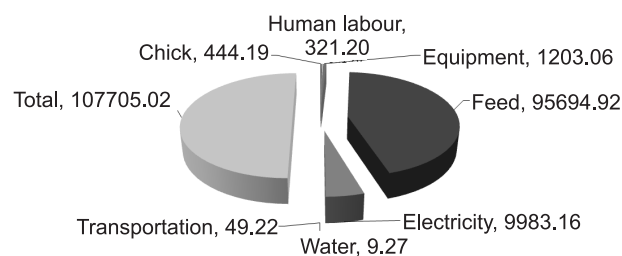

Fig. 1. Energy input ratio in broiler chickens raised (MJ/1,000 bird).

Table 1. Energy equivalences for inputs and outputs

Inputs and outputs	Unit	Energy equivalent coefficient	References
Inputs	Unit	Values (MJ/unit)	
Chick	kg	10.33	Najafi *et al.* 2008
Human	h	1.96	Karaagac *et al.* 2011 Mani *et al.* 2007
Equipment (Plastic)	kg	90	Canakci and Akinci, 2006
Equipment (Iron)	kg	27.73	Canakci and Akinci, 2006
Feed			
Organic diet (1st week)	kg	12.98	Calculated
Organic diet (2nd week)	kg	12.97	Calculated
Organic diet (3th week)	kg	13.40	Calculated
Organic diet (4th week)	kg	13.73	Calculated
Electricity	kWh	3.60	Ozkan *et al.* 2004
Water	ton	0.63	Yaldiz *et al.* 1993
Transportation	MJ (ton/km)	9.22	Acaroglu, 2004
Inputs			
Broiler	kg	10.33	Celik and Ozturkcan, 2003
Manure	kg	0.30	Singh, 2002

Energy efficiency calculations in broiler chickens raised are given in Table 4. The inputs used in the production of broiler chickens for direct, indirect, renewable and non-renewable energy groups were distributed (Table 5). Benefit-cost ratio of the broiler chickens production are given in Table 6.

Nabavi-Pelesaraei *et al.* (2013) reported energy use efficiency, productivity and specific energy respectively as 0.11, 0.01 kg/MJ and 84.53 MJ/kg; Sefat *et al.* (2014) 0.15, 0.01 kg/MJ, 76.59 MJ/kg; Heidari *et al.* (2011) 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. In addition, net energy (Sefat *et al.* 2014) and energy use efficiency (Najafi *et al.* 2008) were calculated as −189,769 MJ/1,000 bird and 0.25, respectively. Heidari *et al.* (2011) reported that it is possible to increase the energy ratio by raising the meat yield and reducing the energy inputs. Similar to feed consumption, these also contain diets low on protein, high in fibre and low in lysine.

Our results, in terms of energy efficiency and productivity, were higher than the results of the previous studies but lower in terms of specific energy and net energy. To achieve sustainable agriculture, it is important to use

Table 2. Composition of the diets used in trial

Ingredients (%)	Organic diet 1 (1st week)	Organic diet 2 (2–4th week)	Organic diet 3 (5–7th)	Organic diet 4 (8–10th)
Maize	52	54	62	65
Soybean meal, (CP 44%)	38.70	37	28.80	27.80
Fish meal	3	3	3	-
Vegetable tallow	4	3.70	3.90	4.90
Limestone	-	-	-	-
Dicalcium phosphate	2	2	2	2
Salt	0.30	0.30	0.30	0.30
Vitamins and minerals	-	-	-	
Metabolisable energy (MJ/kg)	12.98	12.97	13.40	13.73
Crude protein (%)	23.70	23.10	20.20	18.08
ME (kcal/kg)	3102.8	3100	3202	3280

Table 3. Energy input-output analysis in broiler chickens raised

Inputs	Unit	Quantity/ unit (1,000 bird)	Total energy equivalent (MJ/1,000 bird)	Ratio (%)
Chick	kg	43	444.19	0.41
Human labour	h	163.88	321.20	0.30
Equipment			1203.06	1.12
Plastic	kg	12.84	1156.40	1.07
Iron	kg	1.68	46.66	0.04
Feed			95694.92	88.85
Organic diet (1st week)	kg	181.23	2352.36	2.18
Organic diet (2nd week)	kg	1632.20	21169.63	19.66
Organic diet (3th week)	kg	2711.57	36335.03	33.74
Organic diet (4th week)	kg	2610.19	35837.90	33.27
Electricity	kWh	2773.10	9983.16	9.27
Water	ton	14.73	9.27	0.01
Transportation	MJ	5.34	49.22	0.05
Total inputs			107705.02	100.00
Outputs	Unit	Quantity per unit (1,000 bird)	Total energy value (MJ/ 1,000 bird)	Ratio (%)
Meat	kg	3045.36	31458.56	97.86
Manure	kg	2295	688.50	2.14
Total outputs			32147.06	100.00
Energy ratio			0.30	

Table 4. Energy input-output and efficiency calculations in broiler chickens raised

Indicator	Unit	Value
Yield (meat)	kg	3045.36
Energy input	MJ/1,000 birds	107705.02
Energy output	MJ/1,000 birds	32147.06
Energy use efficiency		0.30
Energy productivity	kg/MJ	0.03
Specific energy	MJ/kg	35.36
Net energy (-)	MJ	75557.96

Table 5. Energy input in the form of direct and direct renewable and non-renewable energy for broiler chickens raised

Type of energy	Energy input (MJ/1,000 bird)	Ratio (%)
Direct energy[a]	10313.63	9.57
Indirect energy[b]	97391.39	90.43
Total	107705.02	100.00
Renewable energy[c]	96469.58	89.57
Non-renewable energy[d]	11235.44	10.43
Total	107705.02	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.

Table 6. Net return and benefit-cost ratio of the broiler chickens production

Cost and return components	Value
Yield (kg/1,000 bird)	3045.36
Sale price (TL/kg)	10
Gross value of production (TL/1,000 bird)	30453.60
Variable cost of production (TL/1,000 bird)	10407.35
Fixed cost of production (TL/1,000 bird)	2236.02
Total cost of production (TL/1,000 bird)	12643.37
Total cost of production (TL/kg)	4.15
Gross return (TL/1,000 bird)	20046.25
Net return (TL/1,000 bird)	17810.23
Benefit-cost ratio	2.41

1 US$, 2.17 TL in 2014 (average).

energy efficiently. Energy use in agriculture is rising as a consequence of growing population levels, lack of arable land, as well as a common desire to enjoy higher life standards (Kizilaslan 2009). This means that organic production increases energy use efficiency, and it does not meet the consumer demand. Because the price of organic production can be as high as three-times the conventional one (Cobanoglu *et al.* 2014).

The total energy input consumed can be categorized as 9.57% direct, 90.43% indirect, 89.57% renewable and 10.43% non-renewable for broiler (Table 5). The result of broiler chicken production analysis in economic terms are given in Table 6.

It is determined by dividing the total cost of broiler

chickens production/kg by the broiler chicken meat yield/kg. To determine the net return, total cost of producing/kg (variable + fixed cost) was subtracted from the production gross value (Demircan *et al.* 2006). The cost of broiler chicken production/kg expressed in TL, which was equal to 0.46 USD in 2014. Gross return was determined by subtracting the variable cost of production per (TL/1,000 bird) from the gross value of production TL/1,000 bird and determined as TL/(1,000 bird). Regarding the study area, profit margin of broiler chicken per kg (TL/kg) was calculated as 5.85. Based on these results, it is possible to say that the net return of broiler chickens production yielded satisfactory results. It can be concluded that for every 1 TL invested, the net return was 2.41 TL, and it was cost effective business according to the 2014 production season data.

Evaluation of the results on energy balance of broiler chickens indicated that broiler chickens raised under organic conditions were not an economic type of production in terms of energy use. In terms of agriculture, there are 2 ways of reflecting optimal energy consumption (a) increasing productivity through existing levels of energy inputs; or (b) maintaining energy without harming productivity (Azizi and Heidari 2013).

Modern scientific applications must be used to ensure higher productivity levels of energy and highest yield from broiler production. The significance of energy utilization cannot be emphasized enough. The desired levels of energy saving is not possible unless energy utilization is recorded accurately (Heidari *et al.* 2011).

To increase energy ratio, one can manage consumption of electricity and fuel. Feed rate was the top ranked in total energy input. To reduce feed energy input, chicks should not be stressed. To increase total output energy, bird production number should be increased. The economic analysis of broiler chickens production was concluded upon the selling price and total cost of producing. Benefit-cost ratio was determined as 2.41. The net return from organic broiler chicken production is satisfactory. Organic broiler chicken production is not an economic production in terms of energy usage.

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