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Comparative study on energy consumption and cost analysis of fattening farms under different farm sizes in Qazvin city of Iran

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ABSTRACT

The study was carried out for determine the amount of input- output energy used and indices of energy and economic of fattening farms under different farm sizes in Qazvin city of Iran. For this purpose the data were collected from 30 fattening farms. The surveyed farms were classified into three groups of small (less than 50 heads), medium (50 to 150 heads) and large farms (more than 150 heads).The total average energy input of 24003 MJ calf $^{-1}$ was required for fattening farm. The share of feed by 75% of the total energy inputs was the highest energy input. This was followed by fossil fuels (16%) and young calf (4%), respectively. The energy use efficiency, energy productivity, Specific energy, and net energy were found as 0.009 (kg MJ^{-1}), 114.8 (MJ kg^{-1}) and -20553(MJ calf^{-1}), respectively. According to the study results, the contribution of indirect energy was higher than that of direct energy; also the share of renewable energy was more than that of non-renewable energy. Economic analysis showed that total average cost of production was 909.8 (\$ calf^{-1}). The benefit-cost ratio and productivity were 1.1 and 0.22 (kg \$$^{-1}$), respectively. The results showed that medium farms in terms of economic and energy indexes lower position than the small and large farms. So, they should change their scale to achieve higher efficiency.

Introduction

With the increase in world population, has increased beef consumption. Considering to the high demand and lack of accountability traditional system of meat production to this demand, to increase the amount of performance is requiring the use of industrial equipment instead of using traditional methods and human force. However, intensive use of energy causes problems threatening public health and environment. So be attentive to how on the energy consumption is essential in the meat production. Modern farming has become very energy intensive; therefore there is a great need to balance the use and availability of energy (Singh et al., 2000). The energy input–output analysis is usually for determine and provide a balanced pattern for the production and use of energy. As well as energy analysis allows the energy cost of existing process operations to be compared with that of new or modified production lines (Jekayinfa, 2007). Several studies have been done in relation to the energy input–output analysis of meat production units that some of them are mentioned below.

Researchers calculated the energy consumption to process one pound of meat (Ramirez et al., 2006). Najafi et al. (2012) determined the amount of input–output energy used in broiler production farms in different farm sizes. Heidari et al. (2011) investigated the energy use pattern and economic analysis of broiler production in Yazd province of Iran. Their results showed the Total input energy was calculated about 186886 (MJ 1000 birds^{-1}) while the output energy was about 27461 (MJ 1000 birds^{-1}). Using energy analysis, researchers found that the total quantities of energy consumed and produced in one rearing period of broilers in Alborz Province during winter were 218.40 and 30.13 GJ per thousand broilers, respectively. Inputs such as gas oil, feed, natural gas, and electricity with 40, 25, 23 and 9 percent of the total consumed energy, respectively, were the most energy consuming inputs in broiler production in the province (Almasi et al., 2014).

Although, meat of calf is an important source of proteins, minerals and vitamins for human diet and have high consumption, but there is no study about energy analysis for meat of calf production and fattening farms of calf in Iran. Therefore, this study is done with the aim of analyze the energy consumption, providing the pattern of energy consumption and finding energy indices in fattening farms of Qazvin city of Iran.

Materials and methods

Data collection

This study was conducted in Qazvin city of Iran. Data were collected through personal interview method in a specially designed schedule for this study.

The collected data belonged to the 2014 production year. The questionnaires included information about utilized inputs for one period of fattening, like total feed and fossil fuels consumptions, total working hours of labors, total electricity consumption, etc. and also the yield per calf at the end of the period. The sample size was calculated 30 fattening farms (with fattening period of 6 to 12 months of calf) using Cochran's technique (1977). For the analysis of energy use in different farm sizes, the selected farms were classified into three categories as small (<50 heads) medium (between 50 and 150 heads) and large farms (>150heads).

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Energy equivalents used

In units of fattening farms of calf, fossil fuels (diesel, oil, gasoline and natural gas), machinery, equipment, electricity and feed for calf, human labor and young calf (live weight) were inputs and manure and fattened calf (live weight) were considered as output. To convert the input used in fattening of calf to equivalent energy consumption have been used from the coefficient of energy that value of these coefficients has been shown in Table 1. After multiplying the value of each input or output in its corresponding energy equivalent, their energy values were determined. For the estimate energy equivalent of machinery and equipment was used from the equation (1) (Gezer et al., 2003):

Where '*ME*' is same energy machinery and equipment, '*E*' the production energy of machine that is shown in Table 1,

$$ME = \frac{G \times M_P \times t}{T} \tag{1}$$

'*L*' the useful life of machine (year), '*G*' the weight of machine and '*T*' the economic life of machinery.

Table 1. The energy content of the inputs and outputs of fattening farm.

Items (unit)	**Energy content (MJ Unit^{-1})**	**References**
A. Inputs		
1. Tractor (kg a *)	9-10	(Kitani, 1999)
2. Equipment and machinery (kg a)	6-8	(Kitani, 1999)
3. Fossil fuels		
4. Diesel (l)	47.8	(Kitani, 1999)
5. Gasoline (l)	46.3	(Kitani, 1999)
6. Oil (l)	36.7	(Kitani, 1999)
7. Natural gas (m^3)	49.5	(Kitani, 1999)
8. Electricity (kWh)	11.93	(Ozkan et al., 2004)
9. Labor (h)	1.96	(Kitani, 1999)
10. Young calf (kg) ***	6.5	(Frorip et al., 2012)
11. Feed **		
(a) Concentrate (kg)	13.6	(Frorip et al., 2012)
(b) Maize silage (kg)	10.41	(NRC, 2001)
(c) Dry Alfalfa (17% CP) (kg)	10.92	(NRC, 2001)
(d) Barley (kg)	15.28	(NRC, 2001)
B. Outputs		
1. Fattened calf (kg) ***	9.22	(Frorip et al., 2012)
2. Cow manure (kg dry matter)	0.3	(Singh and Mittal ,1997)
*: Economic life of machine		
**: Metabolizable energy		
***: Live weight		

Energy and economic indicators

Following the calculation of energy input and output values, the energy ratio (energy use efficiency), energy productivity and net energy were determined (Nabavi-Pelesaraei et al., 2013b; Mohammadi et al., 2008):

$$E.R = \frac{E_{out}}{E_{in}} \tag{2}$$

$$NEG = E_{out} - E_{in} \tag{3}$$

$$EP = \frac{Y}{E_{in}} \tag{4}$$

$$SE = \frac{E_{in}}{Y} \tag{5}$$

Where, '*E.R*' is energy use efficiency; '*NEG*' is net surplus energy (MJ per head of calf), '*EP*' is energy productivity (kg MJ^{-1}), '*SE*' is specific energy (MJ kg^{-1}), 'E_{in}' is energy input of the system (MJ per head of calf), 'E_{out}' is energy output of the system (MJ per head of calf) and '*Y*' is the yield (kilograms of product per head of calf).

For the growth and development, energy demand in various agricultural sectors can be divided into direct and indirect or renewable and nonrenewable energies (Alam et al., 2005). In fattening farms , direct energy includes human labor, fossil fuels (for heating, pumping the water, adjusting of machinery , equipment and diesel electric motor) and electricity (for pumping the water, lighting and adjusting of electrical equipment) while indirect energy includes energy embodied in feed, young calf and machinery. Renewable energy consists of human labor, feed and young calf whereas nonrenewable energy includes fossil fuels, machinery and electricity.

In the end of this study economic indicators was studied and analyzed of fattening farms in different farm sizes. In fattening farms were calculated two types of fixed and variable costs. The fixed costs were the amount of capital gains, depreciation, Insurance and etc. for one fattening period. The variable costs were costs of human labor and the cost of used materials such as young calf, fuel, feed, electricity, drug and veterinary services. Sum of fixed and variable costs is the total cost of fattening farms. The net return was calculated by subtracting the total cost of fattening farms from the gross income of fattening farms per one fattening period. The Benefit -cost ratio was calculated by dividing the gross value of production by the total cost of fattening farms per head calf. The economics indices were calculated by following equations (Mohammadshirazi et al., 2012; AghaAlikhani et al., 2013; Nabavi-Pelesaraei et al., 2013a;Soltanietal.,2014).

$$\text{Gross return} = \text{Gross production value } (\$\ calf^{-1}) - \text{Variable production cost } (\$\ calf^{-1}) \tag{6}$$

$$\text{Net return} = \text{Gross production value } (\$\ calf^{-1}) - \text{Total production cost } (\$\ calf^{-1}) \tag{7}$$

$$BC = \frac{\text{Gross Production value } (\$\ calf^{-1})}{\text{Total production cost } (\$\ calf^{-1})} \tag{8}$$

$$\text{Productivity} = \frac{\text{Yield } (kg\ calf^{-1})}{\text{Total production cost } (\$\ calf^{-1})} \tag{9}$$

Basic information on energy inputs, costs and economical indices of fattening farms were entered into Excel 2013 spreadsheets and SPSS 20.0 software program.

Results and Discussion

Analysis of input- output energy use in fattening farm

The inputs and outputs energy equivalent of three different sizes fattening farm is given in Table 2. The Average total input energy was calculated as 24003 (MJ calf^{-1}) during the fattening period of fattening farms. Average total output energy was calculated as 3450 (MJ calf^{-1}). This energy was much less than total inputs energy which confirms this fact that the livestock production is the poor converter of energy because it is based on a double energy transformation. First, solar energy and soil nutrients are converted into biomass by green plants. When crops are fed to livestock, a major share of energy intake is spent on keeping up body metabolism and only a small portion is used to produce meat and milk (Frorip et al., 2014). The greatest shares of input energy with 17951(MJ calf^{-1}) and 3823 (MJ calf^{-1}) corresponded to the average feed intake and fossil fuels, respectively. In other meat production units, the major share of the energy input related with this two inputs. In broiler production in Yazd province in Iran that highest energy factors were fuel (59.20%), feed (31.71%) (Heidari et al., 2011). Amid et al. (2015) showed the most share of energy input were related to fuel (61.48%) and food (34.87%) in broiler production. Amini et al. (2015) and Almasi et al. (2014) also introduced fuel and feed as the most widely used energies inputs in broiler production.

Table 2. The amount of energy input and energy output in fattening farms with different levels

Items	Farm size groups			Average (MJ calf^{-1})	(%)
	Small (<50)	Medium (50-150)	Large (>150)		
A. Inputs					
Tractor and implement and machinery(kg a)	644	456.4	384.3	470.9	2
Fossil fuels (l)	5312	3839	2718	3823	16
Electricity (kWh)	1078	698.5	463.4	706.9	3
Human labor (h)	167.8	134.1	99.127	131.6	0
Feed (kg)	15453	17997	19618	17951	75
Young calf (kg)	845	958.7	870.53	919.2	4
B. Outputs					
Fattened calf (kg)	3243	3207	3304	3236	94
Cow manure (kg dry matter)	209.9	207.3	232.3	213.6	6

The results have shown that units with more than 150 heads of calf have more energy consumption (24154 MJ calf^{-1}) than other units. This units compared to Medium and small units have consumed more energy to amount of 0.288% and 2.77%, respectively. Large units compared to small and medium units 2.41% and 3.57% percent more energy produced.

Analysis of variance in the effect of energy input on energy outputs is given in Table 3. The results of variance analysis showed, between energy consumption and energy output in fattening farm, there is no significant relationship.

Table 3. The variance analysis of the effect of energy input on the energy output of fattening farms

Sources of variations	df	Sum of squares	Mean of squares	F
Output energy	1	17297	17297	1.43^{ns}
Error	28	337498	12153	
Total	29	354796		
ns : lack of significant relationship at the level of 5%				

So increase in the energy input does not effect on the yield.

Analysis of energy indices and forms in fattening farm

The energy use efficiency (energy ratio), specific energy, energy productivity and net energy gain of fattening farm in the Qazvin city were calculated using Eqs. (2)- (5) and the results are shown in Table 4.

The energy ratio gives an indication of how much energy was produced per unit of energy utilized. In this study, energy use efficiency was calculated as 0.14. This amount is represented the less energy efficiency in these units. Of course nature of some products as livestock product is negative net energy in production especially. In several studies on different products in Iran, the energy ratio were calculated as 0.18 (Amid et al., 2015), 0.15 (Almasi et al., 2014), 0.16 (Amini et al., 2015) and 0.15 (Heidari et al., 2011) for broiler production. Compare the results show that the energy ratio in units of production of calf meat is lower compared to units of production of broiler meat.

By raising the meat yield and by decreasing energy inputs consumption the energy ratio can be increased. The results showed, for production per kilogram of meat is required to consumption 114.8 MJ of energy. The less energy is consumed per unit of poultry meat (Almasi et al., 2014; Heidari et al., 2011; Amid et al., 2015; Amini et al., 2015).

Table 4. Energy indicators in fattening farms at different levels

Items	unit	Farm size groups			Average (MJ calf^{-1})
		Small (<50)	Medium (50-150)	Large (>150)	
Energy efficiency	–	0.1469	0.1417	0.1464	0.14
Energy productivity	kg MJ^{-1}	0.0094	0.0083	0.0092	0.009
Specific energy	MJ kg^{-1}	105.9	120.2	107.6	114.8
Net energy gain	MJ calf^{-1}	-20047	-20669	-20616	-20553

The index is calculated for strategic agricultural products as an example is calculated 13.17 (MJ kg^{-1}) for rice (Nabavi-Pelesaraei et al. 2014), 3.97 and 4.72 (MJ kg^{-1}) for potato production (Zangeneh et al., 2010), 7.24 (MJ kg $^{-1}$) for corn (Banaeian and Zangeneh, 2011), 2.2 (MJ kg $^{-1}$) for corn silage (Ajabshirchi, 2013) and 17.80 for wheat and 15.14 (MJ kg $^{-1}$) for barely (Ziaei et al., 2013). In all products listed, this index was much lower than meat production.

Compare the results at different levels show that medium units to produce each kilogram of meat have consumed more energy and less efficient, slightly that it can be attributed to weak management than on this scale.

Distribution of energy consumption of fattening farms on the basis of direct, indirect, renewable and non-renewable energy forms for farms with different sizes are given in Table 5. The average total energy input consumed could be classified as direct energy (19.43%), indirect energy (80.57%) and renewable energy (79.16%) and non-renewable energy (20.84%).

The share of direct energy and non-renewable is in small units 27.90%, 29.93%, in medium units 19.39%, 20.73% and in large units 13.58% , 14.76% that is represent significant savings direct and non-renewable energy in large units.

The results showed that in farms with different sizes, the rate of direct energy was lower than that of indirect energy and the share of non-renewable energy forms was less than that of renewable energy consumption in fattening farm.

Feed is most influential input in amount the DE and RE, so, given the amount of feed intake to be done and prevent from wasting it in various stages of preparation, transportation and distribution. The percentages of these energy forms are shown in Fig. 1

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

Items	unit	Farm size groups			Average (MJ calf^{-1})	(%)
		Small (<50)	Medium (50-150)	Large (>150)		
Direct energy	MJ calf^{-}	6558	4671	3280	4661	19.43
Indirect energy	MJ calf^{-}	16942	19412	20873	19341	80.57
Renewable energy	MJ calf^{-}	16466	19090	20587	19002	79.16
Non–renewable	MJ calf^{-}	7034	4994	3566	5001	20.84
Total energy	MJ calf^{-}	23501	24084	24154	24003	100

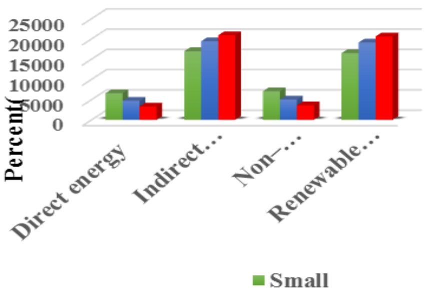

Figure 1. Forms of total energy in different farm sizes of fattening farms

Economic analysis of fattening farms

In order to investigate the meat production in fattening farms, economically, economic analysis was done and the results are given in Table 6. The average variable and fixed cost were 899.3 (\$ calf^{-1}) and 10.57 (\$ calf^{-1}) with share of 98% and 2% of total cost, respectively. The greatest share of the variable costs related to the cost of feed (47%). In Fig. 2 is given, the share of variable costs for per head calf in fattening farms in one period.

The results show that medium farms have a higher total cost for each head of calf during the period. These farms have less income against more cost. This shows the scale used in this unit is not correct. So, these farms according to their position should increase or decrease the number of their calf. The benefit-cost ratio from fattening farms was calculated 1.1. As it is clear this rate is less for medium farms that shows medium farms in the region are more inefficient, economically. Benefit-cost ratio was calculated 1.38 for broiler farms production (Heidari et al., 2011) and 1.09 for potato production (Zangeneh et al., 2010). According to the results calf meat production is profitable industry, relatively that can be better with applied plans and policy in the pricing and marketing of meat and correct education to farmers in respect of the correct use of energy. With increased education and support for farmers and encourage them and create a competitive market can be reached self-sufficient in meat production, greatly.

Table 6. Economic analysis of fattening farms.

Items	unit	Farm size groups			Average (MJ calf^{-1})
		Small (<50)	Medium (50-150)	Large (>150)	
Yield	kg calf^{-1}	221.8	200.38	224.5	209
Variable cost of production	\$ calf^{-1}	853.55	910.75	902.5	899.3
Fixed cost of production	\$ calf^{-1}	11.2	11.09	8.81	10.57
Total cost of production	\$ calf^{-1}	864.7	921.8	911.3	909.8
Total income of production	\$ calf^{-1}	1010	998.8	1029	1007
Gross return	\$ calf^{-1}	156.5	88.07	127	108.5
Net return	\$ calf^{-1}	145.3	76.98	118.2	98
Benefit to cost ration (BC)	–	1.17	1.08	1.12	1.1
Productivity	kg \$$^{-1}$	0.26	0.22	0.25	0.22

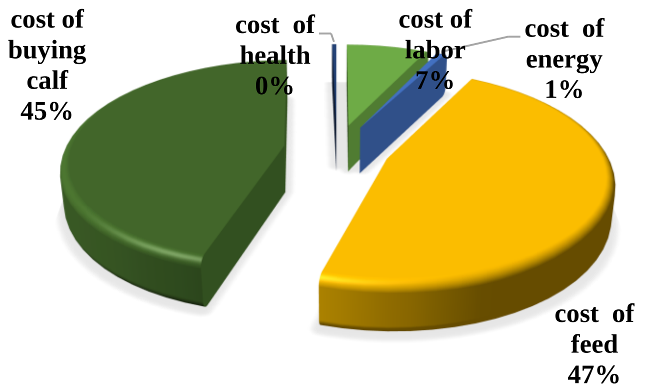

Figure 2. The share of variable costs for per head calf in fattening farms

Conclusion

This study calculated and analyzed the input and output energy and energy and economic indicators of fattening farms in small, medium and large. The results showed that total energy consumption of fattening farms was to be 24003 MJ calf $^{-1}$ in which feed (75%) was the largest energy input, followed by fossil fuels (16%). The least energy consumption belongs to labor. The comparison of energy inputs consumption based on farm size showed that large farms use the more amount of total energy. Total energy output was 3450 (MJ calf^{-1}) that large farms had the highest energy output. Energy use efficiency, energy productivity, specific energy and net energy were found to be 0.14, 0.009 (kg MJ^{-1}), 114.8 (MJ kg^{-1}) and -20553(MJ $calf^{-1}$), respectively. Energy use efficiency was calculated as 0.14 for fattening farms. The analysis of three groups of farms showed medium farms to produce each kilogram of meat have consumed more energy and less efficient. The share of direct energy and non-renewable is in small units 27.90%, 29.93%, in medium units 19.39%, 20.73% and in large units 13.58%, 14.76% . The average value of total cost of production, gross return, net return, benefit-cost ratio and productivity of fattening farms calculated to be 909.8 (\$ $calf^{-1}$), 108.5 (\$ $calf^{-1}$), 98 (\$ $calf^{-1}$), 1.1 and 0.22 (kg $\$^{-1}$), respectively. Medium farms are more inefficient in the study area, economically and from the aspect of energy. This shows the scale used in this unit is not correct and these farms should increase or decrease the number of their calf according to their position. The largest share in energy consumption and costs related to feed. Therefore, farmers should to avoid from wasting it as far as possible. Mixer feeders can prevent from wasting feed in various stages of preparation and distribution, partially. Government support and reassurance to farmers for the purchase of the product can help to prosper this industry, greatly.

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