ENERGY USE EFFICIENCY IN DAIRY FARMING OF TAMILNADU

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ABSTRACT

A study was undertaken to assess the energy use pattern in cow milk production based on the primary data collected from sixty dairy farmers from Kancheepuram district of Tamil Nadu. The results revealed that the highest input energy per animal per day was noticed in large farms (182.59 MJ), followed by medium farms (178.30 MJ), small farms (159.38 MJ) with the overall average of 173.85 MJ. Of all the input energy components, green fodder occupied a major share (61.92 %), followed by concentrate (23.49 %), veterinary expenses (8.34 %), dry fodder (3.78 %) and human labour (2.22 %). Average output energy per animal per day was the highest in large farms as the milk yield was higher (18.17 MJ), followed by small farms (15.32 MJ) and medium farms (15.02 MJ) with the overall average output energy of 15.83 MJ. Out of the total output energy, 83.83 % was from milk and the rest from manure. The results of energy ratio indicated that, small and large farms were having the higher energy ratio of 0.10 compared to energy ratio of medium farms (0.08). Regarding the energy productivity, large farmers were more productive with 100 MJ of energy, 3 litres of milk was produced. Regarding the factors influencing the energy use efficiency of dairy farms, the parameter estimates of the determinants of energy productivity showed that variable farm size (number of animals) and breed were found to be significantly influencing the energy productivity.

Key words: Dairy farm, Energy use, Inputs and output, Energy ratio

1. INTRODUCTION

Among different enterprises of livestock, dairying is the most ancient occupation established in the rural setting of our country. It contributes significantly in generating employment opportunities and supplementing the income for small and marginal farmers and landless labourers, besides contributing to food security. With the dominant presence of livestock population, there is no doubt that it can contribute best to the employment of rural areas.

For many decades, the entire attention had been on increasing the milk production of the country to meet out the growing economic and nutritional demand of population primarily led by the raise in population, changes in life style of people, the rise in per capita income together with industrialization and urbanization. However, no attention was given for utilization of resources in producing the output that had resulted in depletion of natural resources. The livestock feed resources such as fodder and pasture which was liberally and abundantly available has now become insufficient and dearer as the common property resources have been dwindled due to the translation of agricultural land for various monetary requirements. Under these state of affairs, the focal point of policy makers has now shifted to use of resources on energy terms rather than on production terms. Hence, the present study was designed to estimate the input energy utilized in milk production and to know how efficiently the resources are utilized in producing the maximum output.

2. MATERIALS AND METHODS

The study was conducted in Kancheepuram district of Tamil Nadu. For collection of data, a multi-stage random sampling design (I stage - selection of blocks and II stage selection of villages) was used. From 13 blocks of Kancheepuram district, two blocks (Thiruporur and Wallajabad) were selected by simple random sampling. From each selected block, a sample of six villages was selected by simple random sampling technique. Thus, a total of 12 villages were selected from the selected blocks of Kancheepuram district. From each of the selected villages, a total of 5 respondents were selected. Information pertaining to various aspects of dairy farming was collected from selected farmers by survey method with a well designed and pre-tested interview schedule. Details of input used in dairy production like quantity of green fodder, dry fodder and concentrates given per day together with cost, labour hours spent per day together with wage particulars and veterinary and breeding expenses were collected. The data on outputs like milk and manure produced per day and the returns accrued from them were collected.

2.1 INPUT AND OUTPUT ENERGY CALCULATION

As per the study by Ramachandra and Nagarathna (2001), the inputs selected for calculating input energy included those inputs that is utilized within the farm and excluded the inputs involved in the production of that particular input (i.e. the energy consumed in the production of concentrates was excluded and the energy consumed in the consumption of concentrate by the dairy animal was included). For the present study, the input energy included energy from human labour hours spent per day for activities like cleaning the shed and animal, milking, marketing the milk to co-operative societies and health care; energy from feeds and fodder which included dry fodder, green fodder and concentrates; the amount of electricity utilized for various purposes like milking and lighting system in the shed. For calculation of output energy, the main output of dairy farming viz., milk and manure were taken. The energy equivalents for various inputs and outputs are given in Table 1 and the physical data collected were accordingly converted into energy equivalents

Table 1. *Energy equivalents of the inputs and outputs*

Particulars	**Physical unit**	**Energy equivalents in MJ**
Human labour hour	8 hours equals one adult man days	15.68 (Saini *et al.* 1998)
	one hour	1.96
Ground nut cake	Kg	16.16 (Saini *et al.* 1998)
Readymade mix	Kg	13.68 (Saini *et al*. 1998)
Wheat bran	Kg	12.44 (Saini *et al*. 1998)
Feed	Kg	12.60 (Sun *et al*. 2006)
Rice straw	Kg	3.77 (Saini *et al*. 1998)
Green grass	Kg	14.35 (Sun *et al*. 2006)
Pulses	Kg	14.70 (Ozkan *et al*. 2004))
Electricity	kWh	3.60 (Sun *et al*. 2006)
Veterinary expenses	1 Rs.	13.78 (Sun *et al*. 2006)
Buffalo milk	Litre	4.63 (Saini *et al*. 1998)
Cow milk	Litre	2.81(Saini *et al*. 1998)
Manure	Kg	0.30 (Saini *et al*. 1998)

2.2 ESTIMATION OF ENERGY USE EFFICIENCY

The energy use efficiency was estimated by using energy ratio, energy productivity and specific energy. Energy ratio is the ratio of total output energy to total input energy (Ramachandra and Nagarathna 2001 and Meul *et al.* 2007). Energy productivity is amount of product produced with one unit of energy (Meul *et al.* 2007 and Kalbande and More 2008).

$$\text{Energy productivity (litre/MJ)} = \frac{\text{Milk yield in litre}}{\text{Input energy (MJ)}}$$

Specific energy is widely used in energy analysis to express the quantity of energy invested to produce a unit quantity of the product (Kalbande and More 2008).

$$\text{Specific energy} = \frac{\text{Input energy (MJ)}}{\text{Milk yield in litre}}$$

2.3 Factors influencing the energy use efficiency of dairy farming

Multiple linear regression analysis was used to analyze the factors affecting the energy use efficiency in cow dairy farming in the study area. Energy productivity was taken as the dependant variable and the explanatory variables were age of the farmer, occupation, education of the farmer, land holdings, gender of the farmer, farm size and breed of the animal.

Where,

$Y = f(X_1, X_2, X_3, X_4, X_5, X_6, X_7)$

Y = Energy productivity (litre/MJ)

X_1 = Age of the farmer (in years)

X_2 = Dummy variable for occupation of the farm
(1- livestock as primary occupation and 0 - otherwise)

X_3 = Dummy variable for education of the farmer
(0 - illiterate, 1- primary education, 2 - secondary education and 3 – collegiate)

X_4 = Land holding in acres

X_5 = Dummy variable for gender of the farmer
(1- male and 0 – female)

X_6 = Farm size (Number of dairy animals)

X_7 = Dummy variable for breed of the dairy animal
(1 - Crossbred cow and 0 – non-descript cow)

The mathematical form of the model can be written as,

$$Y = \alpha+\beta_1X_1+\beta_2X_2+\beta_3X_3+\beta_4X_4+\beta_5X_5+\beta_6X_6+\beta_7X_7+ U$$

α = constant term

$\beta_1, \beta_2, \beta_3, \beta_4, \beta_5, \beta_6$ and β_7, are coefficients to be estimated

U = random disturbance term; (μ_i ~0, σi2)

3. RESULTS AND DISCUSSION

The details of the results of total input and output energy of cow dairy farming are given in Table 2.

Table 2. *Input and output energy in cow dairy farms (in MJ/animal/day)*

Particulars	Category of farmers			
	Small	Medium	Large	Overall
Input energy				
Human labour	5.84 (3.67)	3.25 (1.82)	2.65 (1.45)	3.86 (2.22)
Green fodder	97.33 (61.06)	109.89 (61.63)	116.16 (63.62)	107.65 (61.92)
Dry fodder	6.22 (3.90)	6.35 (3.57)	7.58 (4.15)	6.57 (3.78)
Concentrates	37.95 (23.81)	40.76 (22.86)	44.92 (24.60)	40.83 (23.49)
Electrical energy	0.19 (0.12)	0.67 (0.37)	0.18 (0.10)	0.43 (0.25)
Veterinary expenses	11.85 (7.44)	17.38 (9.75)	11.10 (6.08)	14.50 (8.34)
Total input energy	159.38 (100.00)	178.30 (100.00)	182.59 (100.00)	173.85 (100.00)
Output energy				
Milk	12.87 (84.00)	12.39 (82.50)	15.62 (85.97)	13.27 (83.83)
Manure	2.45 (16.00)	2.63 (17.50)	2.55 (14.03)	2.56 (16.17)
Total output energy	15.32 (100.00)	15.02 (100.00)	18.17 (100.00)	15.83 (100.00)

(Figures in parentheses indicate percentage to total)

3.1 Input Energy Calculation

In case of cow dairy farming, the highest input energy per animal per day was noticed in large farms (182.59 MJ), followed by 178.30 MJ in medium and 159.38 MJ in small farms and the overall average input energy was estimated to be 173.85 MJ. From the results given in the Table 2, it is clear that green fodder was the major energy input component by 61.92 %, followed by concentrate feed (23.49 %), veterinary expenses (8.34 %), dry fodder (3.78 %) and human labour (2.22 %). Contribution of electric energy to the total input energy was very less (0.25 %) when compared to the energy contribution from other inputs. The energy from the feeds constituted the major share of total input energy (more than 90 %) and in particular green fodder was the highest contributor to it. On comparing the input energy usage across the size of farm, the energy from feed was utilized more in large farms and the energy from human labour was utilized more in small farms. The results evinced that small farms were utilizing less input energy compared to the medium and large farms.

3.2 Output Energy Calculation

For calculating the output energy, the energy obtained from milk and manure was considered. Average output energy was the highest in large farms as the milk yield was higher (18.17 MJ per animal per day), followed by small (15.32 MJ) and medium farms (15.02 MJ). Out of the total output energy, 83.83 % was contributed by milk and remaining 16.17 % was from manure.

As a whole, it can be concluded that input energy utilized was more than the output energy produced. This is because dairy animals consume more of plant products which are of high energy value and in turn generate animal products of better quality with less energy value resulting in negative net energy output. The fodder and feed utilized by the dairy animal cannot be consumed by human beings. But the dairy animal consumes and in turn producing outputs which are of highly nutritional and economic value to humans.

3.3 Energy Use Efficiency in Cow Dairy Farms

The detail of energy use efficiency of cow dairy farm is given in Table 3. Energy use efficiency of different categories of cow dairy farms was measured by calculating energy ratio, energy productivity and specific energy.

Table 3. *Energy use efficiency of cow dairy farms*

Particulars	Category of farmers			
	Small	Medium	Large	Overall
Total input energy (MJ/cow/day)	159.38 (4.50)	178.30 (3.65)	183.59 (2.60)	173.85 (3.67)
Total output energy (MJ/cow/day)	15.32 (2.46)	15.02 (2.41)	18.17 (3.43)	15.83 (2.64)
Milk yield (litres /cow/day)	4.58 (1.50)	4.41 (1.65)	5.52 (1.45)	4.69 (1.99)
Energy ratio	0.10	0.08	0.10	0.11
Energy productivity (litre/MJ)	0.029	0.025	0.03	0.027
Specific energy (MJ/litre)	34.00	40.43	33.26	37.07

(Figures in parentheses indicate standard deviation)

On comparing the energy ratio between the farms, large and small farms were having the higher ratio of 0.10 compared to medium farms (0.08). Regarding the energy productivity, large farmers were more productive since with one MJ, 0.030 litre of milk was produced which means that with 100 MJ of energy, 3.00 litre of milk was produced. In small farms, with one MJ, 0.029 litre of milk was produced and in medium farms with one MJ, 0.025 litre milk was produced. On analysing the specific energy, it was found that large farms were utilising less specific energy (33.26 MJ) to produce one litre of milk, where as small and medium farms were utilising 34.00 MJ and 40.43 MJ of energy, respectively to produce one litre of milk. In terms of specific energy, large farms are more efficient because these farms are utilising less amount of energy to produce one litre of milk compared to other farms.

3.4 Factors influencing energy use efficiency in cow dairy farms

In order to identify the factors influencing energy use efficiency in milk production, the energy productivity of cow dairy farms were subjected to multiple linear regression analysis having the socio economic variables as the independent variables and the results are presented in Table 4.

Table 4. *Factors influencing the energy use efficiency of cow dairy farms*

Independent variables	Co-efficient	t- value
Constant		-1.465
Age of farmer	0.158*	2.380
Occupation	-0.007	0.092
Education	0.121*	1.980
Land	0.055	0.786
Gender	-0.049	-0.727
Farm size	0.586**	8.333
Breed	0.500**	7.659
R^2	0.82	
Adjusted R^2	0.79	
N	60	
F	32.794	

** Significance at 1 % level (p< 0.01)
* Significance at 5 % level (0.05>p>0.01)

The results of the regression equation show that the co-efficient of multiple determinations (Adjusted R^2) for the estimated equation was 0.790 indicating that 79 % of the variations in the energy productivity of dairy cow farms were explained by the included independent variables.

The parameter estimates of the determinants of energy productivity showed that variables, farm size (number of animals) and breed of the animal were found to be significantly influencing the energy productivity at 1 % level (p<0.01). Other parameters such as age and education were found to be influencing the energy productivity at 5 % level (p<0.05). It could be inferred from the results that as the farm size increased, the energy productivity also got improved, which might be due to improved utilization of idle resources such as labour and economies of scale. In case of breed, as the number of high productive crossbred animals in the farm increased, the energy productivity also got improved. Likewise as the age and education level improved, the experience and skill level of the cow dairy farmers elevated and they were able to utilize the resources optimally that resulted in improved energy productivity.

4. CONCLUSIONS

The results of the study clearly portrayed that large farms were energy efficient compared to small and medium farms which might be due to higher milk yield and better utilization of resources that resulted in economies of scale. On comparing small and medium farms, small farms were highly efficient in energy use efficiency than medium farms as they could able to closely monitor the farm activities than that of medium farms. Regarding the factors influencing the energy use efficiency of dairy farms, the parameter estimates of the determinants of energy productivity showed that variable farm size (number of animals) was found to be significantly influencing the energy productivity and breed was significantly influencing the energy productivity in cow dairy farms.

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