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ASSESSMENT OF THE CARBON MASSFLOW FROM THE LAYER FARMING WITH LIFE CYCLE INVENTORY

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ABSTRACT

Life cycle inventory is a useful tool for estimating carbon mass of the food support eating. Layers were energy using animals that were raised for their egg, and produced emissions of green house gasses such as CO_2 and CH_4. Therefore it was important to study and understand the relationship between the carbon emissions and carbon mass transfer for egg production. This case study of egg production were studied to evaluate carbon emission on layer farms, to investigate the rate of carbon massflow from layer feed to layers and egg in farms and to study the carbon emission in energy patterns from electric energy and petrol used in egg production. The study showed that the weight measurements of layer on farms found that a layer was 1.91 ± 0.15 kg/head at 400.63 ± 109.72 days. The egg weight measurements of layer on farms found was 0.047 ± 0.009 kg/head/day. The study also showed that the carbon emitted per unit from a layer of the young chicken farms and layer farms in Khon Kaen and Nakhon Nayok provinces were 0.004 ± 0.003 and 0.006 ± 0.003 kg.C/individual/day, respectively and the carbon emission from the using of transportation energy was 94.29 %, the carbon emission from the using of electricity energy and the carbon emission from the using of LPG was 2.86 % and 2.86 %, respectively. The productive carbon footprint of 1 kg of egg was 5.612 kg.CO_2.equivalent. The carbon fixation in eggs was 0.013 ± 0.003 kg.C/individual/day, and the rate of carbon massflow from layer feed (C_{input}) of Khon Kaen and Nakhon Nayok provinces were 0.027 ± 0.004 and 0.042 ± 0.004 kg.C / individual / day, respectively. The ratio of total carbon emitted per unit to total carbon contents per unit in layer feed ($C_{emitted}$ / C_{input}) of Khon Kaen and Nakhon Nayok provinces were 14.80 and 14.29, respectively. The ratio of total carbon emitted per day to carbon fixation per day in layers ($C_{emitted}$ / $C_{fixation}$) of Khon Kaen and Nakhon Nayok provinces were 17.39 and 16.67, respectively. The carbon emission from the using of transportation energy was quite high in terms of energy using but low in the using of electricity and LPG activities. Therefore, farmers should reduce emissions from energy consumption such as reduce electricity utilization in layer farming and reduce distance for layer feed and layers transportation to farms. The using of fuel for transportation should be reduced because it creates the highest carbon emission. The result of this study also showed that the average egg weight was 62.8 ± 4.45 g. / egg and 308.11 eggs / head at 80 weeks old of layer. The relation between the average egg weight (g) and phase out of egg laying (weeks) was the average egg weight in gram = 5.4368 * Ln * (phase out of egg laying in weeks) + 44.935 at $R^2 = 0.8388$. The layer had the highest percentage of the rate of egg laying in range 84 - 86 % at 27 - 28 degree Celsius. The relation between the rate of egg laying (%) and temperature (°C) was the percentage of rate of egg laying = 1.5605 * (temperature in °C) ^{4} -172.2 * (temperature in °C) ^{3}+7117.6 * (temperature in °C) ^{2}-130611 * (temperature in °C) + 897897 at $R^2 = 0.1631$.

Keywords: carbon, egg, layer, life cycle inventory.

INTRODUCTION

The importantly economic livestocks have been produced in many areas of Thailand especially pigs, broilers and layers. During the years 2545-2551 (B.E.), pig and layer productions had been increasing which layer production was higher than pig production. Whereas, broiler production had been decreased gradually as shown in Figure-1. Most layer broilers were raised in Nakhon Nayok, Khon Kaen and Chachoengsoa (Department of Livestock Development, 2009). The food production system as a whole is recognized as one of the major contributors to environmental impacts since it is a great consumer of both energy and natural resources.

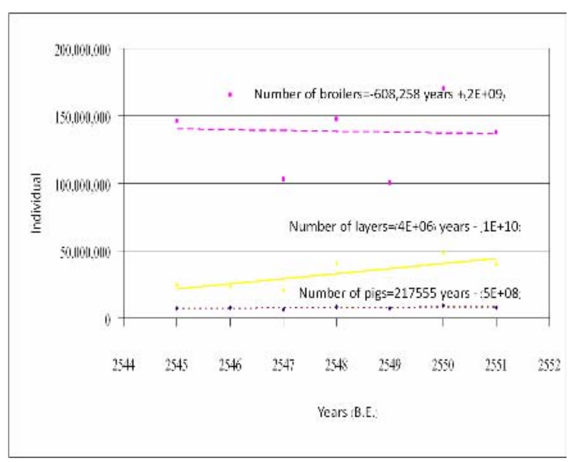

Figure-1. Tendency of pig, broiler and layer productions.

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The current consumption pattern has motivated an increasing interest to report the environmental performance of food products. In this sense, the food production, processing, transport and consumption account for a relevant portion of the environmental greenhouse gas (GHG) emissions. The emissions from food production have increase for two main reasons. First, a growing world population demands more food. Secondly, changes in dietary preferences towards higher-order foods can be increase GHG emissions, with trends towards more intensive of egg production. A growing demand for egg production requires the greater use of the demand for energy. It also induces changes in land use: a process that inevitably leads to CO_2 emissions into the atmosphere. Food production and food consumption are consequently of critical importance in the current and future development of GHG emissions. One of the environmental threats that our planet faces today is the long-term change in Earth's climate and temperature patterns due to global climate change, or the greenhouse effect. CO_2 and CH_4 from human activities are the most important greenhouse gases contributing to global climate change (IPCC, 1995) with CH_4 being 23 times more potent than CO_2 (IPCC, 1996). Chicken and layer are energy-using animals that are raised for their meat and egg, and produce emissions of both CO_2 and CH_4. Carbon is an important element for humans because it is the primary element of both plants and animals and it cycles through living and non-living components. The growth rates of human population drivers the demand of livestock production increase. Livestock animals meet a variety of food needs for people (Thornton *et al*., 2009). They are important nutrient sources of protein in the form of meat and egg (Lauhajinda, 2006). Livestock productions have emitted some greenhouse gases from fertilization, feed production, transportation, energy use in housing, respiration and digestion of livestock (Thanee *et al*., 2009a). The effects of livestock productions due to the utilization and changes of natural resources and environmental factors on the global should be considered (IPCC, 1996). The productive processes should release the least greenhouse gases to avoid such problems and save the Earth. Life cycle inventory (LCI) is an environmental assessment tool for evaluating the impacts that a product has on the environment over the entire period of its life from the raw materials extraction which it was made through the manufacturing, packaging processes, and the use, reuse and maintenance of the product and on to its eventual recycling or disposal as waste at the end of the useful life (Thu Lan and Shabbir, 2008). Layers are energy using animals that are raised for their meat and egg, and produce emissions of CO_2. The carbon emission is an alternative for consumers to select the products that release greenhouse gases emission into the environment (Thanee, Dankitikul and Keeratiurai, 2009b). The net carbon production is the rate at which carbon is fixed during growth and laying eggs, and can be used to explain the time averaged C stocks by carbon weight per time (van Noordwijk and Cerri, *et al*., 1997, van Noordwijk and Murdiyarso *et al*., 1998). Therefore, it is important to study the relevant factors concerning the entire production both physical and biotic environment (Thanee and Keeratiurai, 2010). This study deals with the assessment of the carbon emission for egg products which focused on carbon transferred to food chain and fixed in layer meat and eggs. In particular, the estimation of the rate of carbon massflow from animal feed to layer, and including the carbon emissions from electricity, petroleum, and LPG used during egg production were studied in Thailand.

MATERIALS AND METHODS

Study area

Khon Kaen and Nakhon Nayok provinces were selected which represent egg production of Thailand were based on the data of Agricultural Information Center, Office of Agricultural Economics (2004). These provinces have large areas and provide many layer farms and egg productions in these areas as shown in Figure-2 (Department of Livestock Development, 2009).

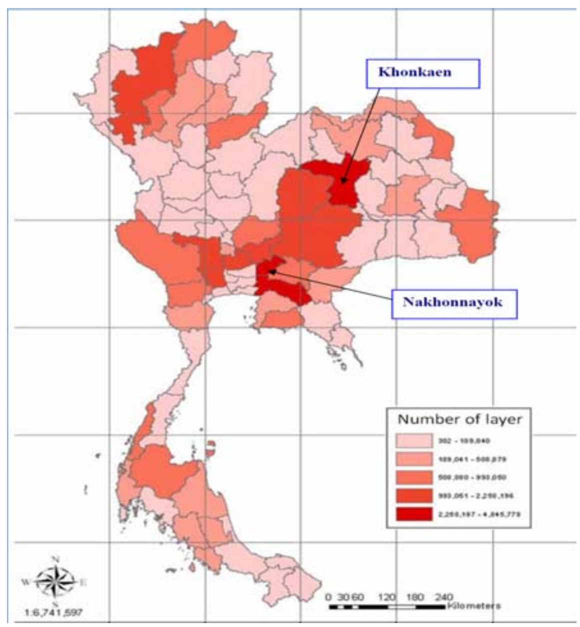


Figure-2. The study of the layer farming area in Khonkaen and Nakhonnayok provinces of Thailand. (From http://www.dld.go.th/index.html, department livestock Development, 2009).

LCI methodology applied in this study

Life cycle inventory analysis involves data collection and calculation procedures to quantify the relevant input and outputs of a product system. These inputs and outputs may include the use of resources and releases pollutant to air, water and land associated with the system (Thu Lan, 2007). Life cycle study, data collection represented a time consuming task and it was important to obtain quantitative information concerning various processes in the product system. A significant part of data associated with life cycle of egg production was collected from chick and layer farms. Data for energy consumption, resources and material were obtained directly from farms. A useful instrument facilitating the estimation of gas emissions was the emission factor, which was a representative value attempts to link the associate with the system output. The process of impact assessment analyzes the environmental burdens associated with the material and energy flows determined in the inventory analysis phase though successive steps listed as follow classification, characterization, normalization and weighting (Curran, 1996).

Site sampling and analytical methods

The numbers of farms, young chickens, and layers in each district of selected provinces were calculated by determining the numbers of farms young chickens, and layers in the Khonkaen and Nakhonnayok provinces at 95% confidence level (Yamane, 1973; Cavana *et al*., 2001). (According to the population of the study, the totals of population study of the tender young chicken farms*, and layer farms were 2039*, and 1383, respectively). Therefore, the sample groups were calculated by Taro Yamane's formula (Yamane, 1973) as follows:

$$n = \frac{N}{1 + Ne^2} \quad (1)$$

Where, n = Sample size
N = Population size
e = The error of sampling

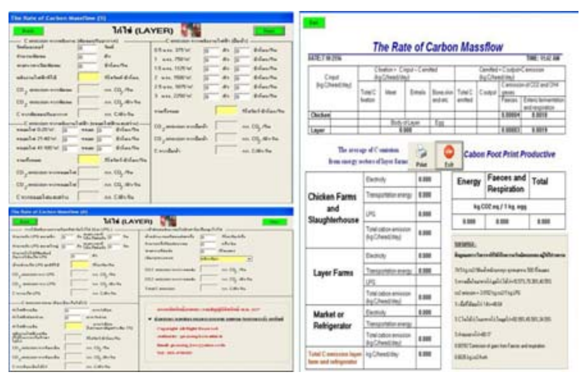
So, the example of the sample size of chick farms for the study has been calculated according to the recommendation as follows:

$n = 2039 / \{1+2039*(0.05)^2\} = 335$ chick farms

With N = 2039, e = 5% (at 95% confidence level), hence the sample size is 335 respondents. The results showed that sample size were 335 young chicken farms, 400 young chickens and 311 layer farms, 400 layers calculated by *Taro Yamane* formula. Animal feed plus their egg and faeces were collected and transferred to the laboratory at Suranaree University of Technology for measurements. Carbon dioxide was measured from living layers at the farms. The evaluation of carbon emission from energy sectors in egg production was calculated with the software of Department of Livestock Development as shown in Figure-3 and the analytical methods are as follows:

a) Moisture contents were measured by weighing sample after oven drying at 103-105°C for 24 hours (APHA, AWWA and WEF., 1992).
b) Carbon contents were measured by CNS-2000 Elemental Analyzer (Manlay *et al*., 2004 b, and Keeratiurai and Thanee, 2013).
c) CO_2 was detected by Gas Analyzer (Kawashima, Terada and Shibata, 2000, and Keeratiurai and Thanee, 2013).
d) Volatile solids and ash were analyzed by weighing the known weight of the sample after burning at 550°C for 30 minutes (APHA, AWWA and WEF., 1992).
e) Weight of layer and egg by weighing (Vudhipanee *et al*., 2002, and Keeratiurai and Thanee, 2013).

(a) The software was used to calculate the carbon massflow from animal feed and carbon emission in energy sectors of the tender young chicken farms and layer farms in egg production.



(b) The software was used to calculate the carbon emission in energy sectors of the layer farms and the results of carbon massflow, emission, and footprint in egg production.

Figure-3. The software was used to calculate the carbon massflow, carbon emission in energy sectors, and carbon footprint in egg production.

RESULTS AND DISCUSSIONS

Life cycle inventory analysis

The result of this study showed that the carbon emission from egg production had 2 stages. The first stage before lay that was the feeding times until the tender young chickens were about 18 weeks old. The second stage was the egg laying that has egg about 2-3 years. With that in each period of stages would be the carbon

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emission from energy using was similar such as the electricity and LPG used on the farms and oil used in transportation.

The weight measurements of layer on farms found that a layer was 1.91±0.15 kg/head at 400.63±109.72 days. The egg weight measurements of layer on farms found was 0.047±0.009 kg/head/day. The study of life cycle inventory to evaluate the total carbon emission for the egg production in Khonkaen and Nakhonnayok, Thailand was shown in Figure-4.

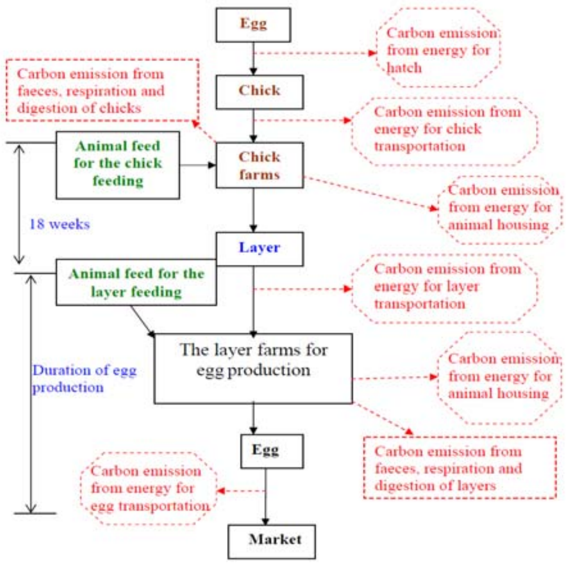

Figure-4. Scope of study on carbon emission from egg production.

Amount of carbon emission and rates of carbon input from layers

The carbon weights in the unit of kilogram carbon per kilogram of animal weight per day (kg.C/kg anim. wt/day) were used to study of carbon massflow from animal feed for feeding to the biomass of layer (C-input). The rate of carbon transference from animal feed for feeding in Khon Kaen and Nakhon Nayok provinces were 0.027±0.004 and 0.042±0.004 kg.C/ind./day, respectively. Carbon fixation was calculated by mass balance. The C-input minus the carbon contents emitted in faeces, enteric fermentation, and respiration (C-emitted) was the carbon mass fixed in the body (C-fixation). The carbon fixation of layer in Khon Kaen and Nakhon Nayok provinces were 0.023±0.004 and 0.036±0.004 kg.C/ind./day, respectively. The carbon emitted from faeces, enteric fermentation, and respiration in Khon Kaen and Nakhon Nayok provinces were 0.004±0.003 and 0.006±0.003 kg.C/ind/day, respectively as shown in Table-1.

A layer had carbon emission at 0.016±0.003 kg.C/kg.ind./day. Most carbon content was in the form of layer faeces at 87.88% of total carbon emission. Carbon content in the form of CO_2 and CH_4 from respiration and digestion of layers was at 11.93% of all total carbon emission.

Table-1. Rates of carbon input, carbon fixation and carbon emission of layer (mean ± S.D.).

Province	Khon Kaen	Nakhon Nayok
C_{input} (kg.C/ind./day)	0.027±0.004	0.042±0.004
$C_{fixation}$ (kg.C/ind/day)	0.023±0.004	0.036±0.004
$C_{emitted}$ (kg.C/ind/day)	0.004 ±0.003	0.006 ±0.003
$C_{emitted}$ /C_{input} (%)	14.80	14.29
$C_{emitted}$ /$C_{fixation}$ (%)	17.39	16.67
Fixation efficiency C = (C_{input} -$C_{emitted}$)/C_{input} (%)	85.19	85.71

The emission of carbon by mass conservation principle which could tell total carbon emission from animal in unit that was ton of carbon per year. The study showed that the rate of total carbon input from food plants to layer by consumption and then fixed in layer bodies, organs, faeces and eggs during rearing duration was shown in Table-2.

Table-2. Average of carbon input (C_{plant}) fixed in layers ($C_{fixation}$) emitted from layers ($C_{emitted}$) in faeces (C_{output}) and C-emitted of CO_2 and CH_4 from respiration and digestion (mean ± S.D).

Amount C transferred from plant food to animal (kg.C/ind/day)			**0.042 ± 0.010**
Carbon fixation (kg.C/ind/day)	**Total C-fixation**		**0.026 ± 0.007**
	Egg		0.013 ± 0.003
	Total C accumulated in body (mass Equilibrium)		0.013 ± 0.004
Carbon emitted (kg.C/ind/day)	Total C-emitted from animal		0.016 ± 0.003
	Dry faeces		0.014 ± 0.003
	C -emission of CO_2 and CH_4	faeces	0.00003 ± 0.00001
		Digestion and respiration	0.0019 ± 0.0000

Figure-5 shows proportion of carbon contents from food plants which are transferred to layers and fixed into parts of layers, faeces and CO_2, CH_4 from digestion and respiration per individual per day. Carbon content at 100 parts in food plants, were fixed in bodies and egg of layers at 62.00%. The rest of carbon contents were released from layers at 38.00%. These carbons created environmental problems.

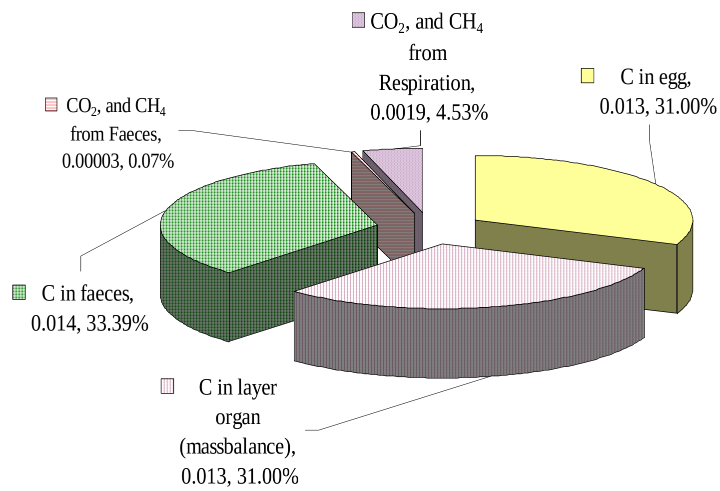

Figure-5. Percentage of C form different parts of layers transferred from plant food per day.

Carbon emission from energy sectors

The survey of farms in studied provinces found that layer farms have used much energy for raising layer per individual per day. Most of energy use including energy for electricity, water pumps, transportation of animals, eggs, feed and animals to slaughterhouses, and LPG or electricity for incubation of baby chicks. Carbon emission from these parts for layer farms was used for feed transportation and small chicks to farms and egg transportation to markets as shown in Table-3.

Table-3. Average of C-emission from energy in layer farm (mean ±S.D).

Average c from energy		**C-emission** (kg.C/ind/day)
Farm	Electricity*	0.002 ± 0.00
	Fuel for transportation**	0.066 ± 0.03
	LPG***	0.002 ± 0.00
Total $C_{emission}$ from energy of farm	kg.C/ind/day	0.07 ± 0.03
	kg.C/wt/day	36.65 x 10^{-3}

Remark: *CO_2 emission = 0.18 kg.C/kWh,
***CO_2 emission from LPG = 3.0102 kg.CO_2/1kg.LPG, and
**CO_2 emission = 74.5 kg.CO_2/1 Ton/500 km (Keeratiurai and Thanee, 2013)

Table-3 showed that the carbon emission from using the transportation energy was 94.29%, the carbon emission from using the electricity energy and the carbon emission from using the LPG was 2.86% and 2.86%, respectively. This study showed that the carbon emission from using the transportation energy was quite high in terms of energy using but low in electricity and the using of LPG activities.

Table-4. Ratio of carbon emission from layers and energy use of farms in egg productions.

Ratio of carbon emitted form	Young chicken	layer
Animal (%)	8.46	18.54
Energy use (%)	91.54	81.46

The result of Table-4 shows that the attempt in decreasing carbon emission from the production of the young chickens and layers, the decrease of energy use should be taken into consideration, for instance, the use of gas or LPG instead of the use of chaff or wood. Gas or LPG creates less ash and greenhouse gases than wood and chaff. LPG releases heat energy about 11, 832-12, 034 Kcal/kg equivalent to electricity at 13.70 kWh/kg whilst chaff releases 0.49 kWh, wood (medium density) at 748.23 ± 116.42 kg/m^3; approximately 0.5 cubic meter compare to electricity 0.21 kWh/kg or one kilogram of chaff released energy at 14.27 MJ/kg (3,410.611 Kcal/kg). Base on chemical reaction, propane, combustion (ratio at 70% of gas production) create energy at 499, 000 Kcal/Kmol as shown in Formula 2.

$$C_3H_8+5O_2 \rightarrow 3CO_2+4H_2O+2086 \text{ MJ/Kmol} \quad (2)$$

The combustion of carbon (in form of wood or chaff) creates energy at 97,000 Kcal/Kmol as shown in Formula 3.

$$C+O_2 \rightarrow CO_2+406 \text{ MJ/Kmol} \quad (3)$$

It can be advised that the farmers should use LPG instead of wood and chaff in order to create higher heat energy and less environmental problems for egg productions.

Carbon footprint and massflow in egg production

The carbon footprint in egg production is presented in Table-5. The results show that the carbon contents in energy pattern are more important for egg production. The productive carbon footprint of 1 kg of egg was 5.612 kg.CO_2.equivalent. Carbon footprint value of Nakhon Nayok was less than Khon Kaen. It can be concluded that transportation distance of layers; layers feed and layer products in Nakhon Nayok which is shorter than in Khon Kaen are the major factors on carbon footprint values.

Table-5. Carbon footprint of egg production.

Animals	Product	Productive carbon footprint		
		Energy	Faeces and respiration	Total
Layer	kg.CO_2-eq./ 1 kg. living weight / day x 10^{-3}	134.383	3.727	138.110
	kg.CO_2.eq./ 1 kg. egg	5.461	0.151	5.612

The relationship of $C_{emitted}$ and C_{input} (Sig.F<0.05) and C_{fixed} and C_{input} (Sig.F<0.05) at egg duration or average age of 400.63 ± 109.72 days with average value at 0.042 ± 0.004 (kg. C/ind./day) were presented in Figure-6 and also as follow:

$$\text{C-emitted}_{layer} = 0.6283 \ (\text{C-input}_{plant}) - 0.0107 \quad (4)$$

$$\text{C-fixed}_{layer} = 0.619 \ (\text{C-input}_{plant}) + 0.0003 \quad (5)$$

Where, C-emitted_{layer} = carbon emitted from layers (kg. C/ind./day)
C-fixed_{layer} = carbon fixation in layers (kg. C/ind./day)
C-input_{plant} = carbon content in animal feed which were transferred to layers by consumption

The example of analysis of the relationship between carbon input to body of layers by consumption (C-input or C_{plant}) and carbon fixation in the term of eggs and in layer (C-fixed) which show positive relation (multiple R=0.95) or relationship at 90.46% (R^2_{adj}=0.90). This can be explained as follows:

H_0: $\beta_1 = 0$ or H_0: C-fixed not depend on C-input by consumption of layers

H_1: $\beta_1 \neq 0$ or H_1: C-fixed depend on C-input by consumption of layers

Hence: $F = \frac{MSR}{MSE} = 3785.211 > F_{0.95;\,1,\,398} = 3.84$.

So => Reject hypothesis (Ho)

Significance F = 2.0874 x 10^{-205} which is less than (α = 0.05)

Implication => Carbon which is fixed in eggs and layer bodies correlated linearly with carbon input in layer by consumption at 95% confidence.

To test hypothesis with y axis by

H_0: $\beta_0 = 0$

H_1: $\beta_0 \neq 0$

P-value = 0.477 > 0.05

=> Accept hypothesis

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It can be concluded that the regression equation of C-fixed and C-input of layer is: $C\text{-fixed}_{layer} = 0.619\,(C\text{-input}_{plant}) + 0.0003$

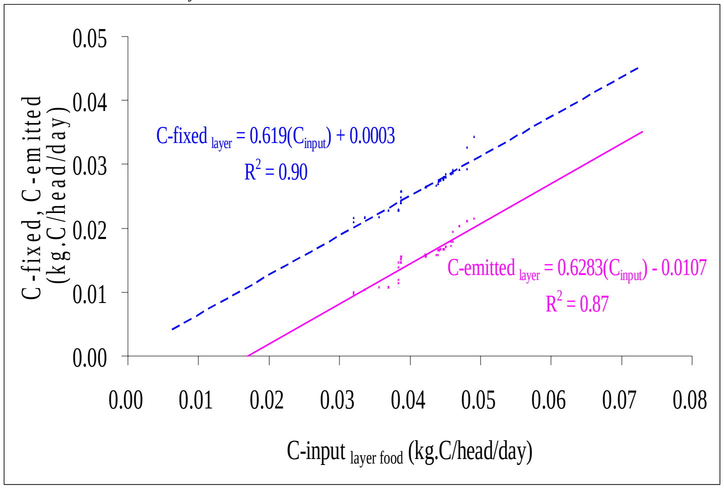

Figure-6. The relationship of $C_{emitted}$ and C_{fixed} to C_{input} at 95% confidence.

Relationship between percentage of carbon and characteristics of feed, egg and faeces, and analysis for environmental problems from animals

Table-6 shows percentage of moisture, volatile solids, ash and carbon content in feed, egg and faeces of layers. Moreover, it shows relationship between percentage of total volatile solids (%TVS) and percentage of carbon (%C) which help in analysis of percentage of carbon in laboratory. The results of this study can analyze environmental problems from egg production.

Table-6. Relationship between moisture, volentile solid and carbon content of food, faeces and egg.

Type	**Moisture** (%)	**TVS** (%)	**Ash** (%)	**C** (%)	**Relationship between % TVS and % C**
Animal feed	10.57 ±0.62	68.31±3.15	31.69±3.15	45.58±4.05	% TVS= 0.73(%C)+ 34.92
Egg	40.55±10.62	92.89±2.51	7.11±2.51	50.99 ±1.17	% TVS= 2.01(%C)-9.43
faeces	70.38 ±12.21	57.85±7.41	42.15±7.41	34.09±2.56	% TVS= 2.37(%C)-22.80

Moreover, the result of this study also showed relationship between the rate of egg laying (%) and phase out egg laying (weeks) was $y = 19.88\ln(x) + 11.22$ at $R^2 = 0.45$ as shown in Figure-7. Layers would start laying eggs when they were aged 18 or more weeks that it was the first week of phase out of egg laying. They would lay most egg in phase out of egg laying at 11-15 weeks. After 43 weeks, the laying egg would likely decline. Therefore, farmers should not been fed to layers for producing eggs from the 61st weeks of phase out of egg laying or at layers aged 80 weeks. Because of the returns was reduced in egg production. Finally, it wasn't worthwhile to continue. The one layer should been able to lay eggs, throughout the life cycle of feeding, was 308.11 eggs / head at the age of layer was 80 weeks or phase out of egg laying was 61 weeks as shown in the Figure-8. It showed the relation between the accumulation number of eggs per individual and phase out of egg laying was $y = 5.4286(x) - 27.605$ at $R^2 = 0.9977$.

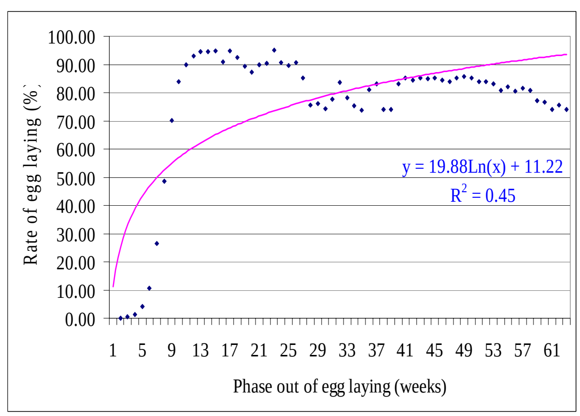

Figure-7. Relation between rate of egg laying (%) and phase out of egg laying (weeks).

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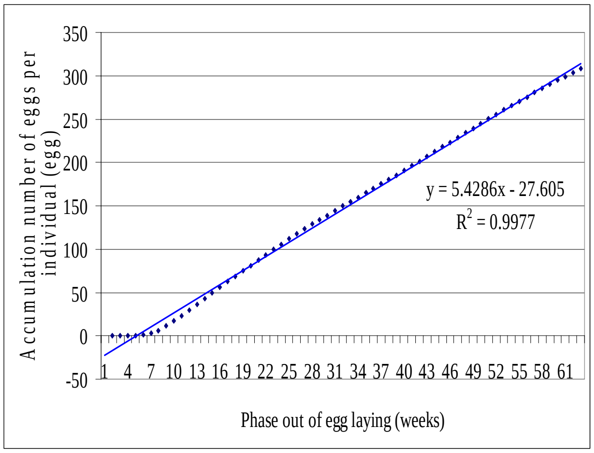

Figure-8. Relation between accumulation number of eggs per individual and phase out of egg laying.

The result of this study also showed that the average egg weight was 62.8±4.45 g./egg and the range of egg weight was 45.0-66.2 g./egg. The weight of the eggs will be very valuable during in phase out of laying eggs from 41 weeks onwards. Figure-9 showed relation between the average egg weight (g.) and phase out of egg laying (weeks) was y = 5.4368Ln(x)+44.935 at R^2 = 0.8388.

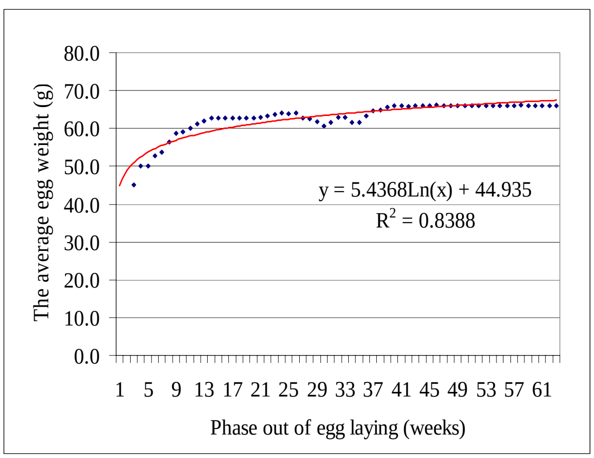

Figure-9. Relation between the average egg weight and phase out of egg laying.

This study surveyed to collect data from farmers who feeding layers in closed house system as evaporation system. It was a system used to control the temperature and the humidity of the house was fixed or variable less. The result showed that the humidity of houses was 74.74 ± 4.04 and temperature in houses was 27.42±0.68 (°C). The layer had the highest percentage of the rate of egg laying in range 84-86% at 27-28 degree Celsius. The relation between the rate of egg laying (%) and temperature (°C) was y = $1.5605x^4-172.2x^3+7117.6x^2-130611x+897897$ at R^2 = 0.1631 as shown in Figure-10.

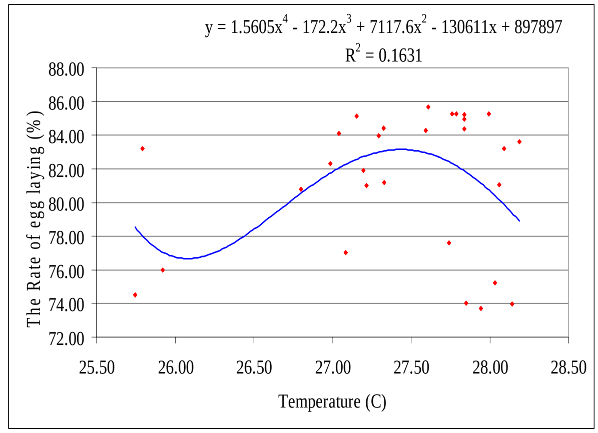

Figure-10. Relation between the rate of egg laying and temperature.

CONCLUSIONS

This case study of egg production was to evaluate carbon emission on layer farms, to investigate the rate of carbon massflow from layer feed to layers and egg in farms and to study the carbon emission in energy patterns from electric energy and petrol used in egg production. The study showed that the carbon emitted per unit from a layer of the young chicken farms and layer farms in Khon Kaen and Nakhon Nayok provinces were 0.004 and 0.006 kg.C/individual/day, respectively and the carbon emission from the using of transportation energy was 94.29%, the carbon emission from the using of electricity energy and the carbon emission from the using of LPG was 2.86% and 2.86%, respectively. The carbon fixation in eggs was 0.013 kg.C/individual/day, and the rate of carbon massflow from layer feed (C_{input}) of Khon Kaen and Nakhon Nayok provinces were 0.027 and 0.042 kg.C/individual/day, respectively. The productive carbon footprint of 1 kg of egg was 5.612 kg.CO_2.equivalent. The ratio of total carbon emitted per unit to total carbon contents per unit in layer feed ($C_{emitted}/C_{input}$) of Khon Kaen and Nakhon Nayok provinces were 14.80 and 14.29, respectively. The ratio of total carbon emitted per day to carbon fixation per day in layers ($C_{emitted}/C_{fixation}$) of Khon Kaen and Nakhon Nayok provinces were 17.39 and 16.67, respectively. The relationship of $C_{emitted}$ and C_{input} (Sig.F<0.05) and C_{fixed} and C_{input} (Sig.F<0.05) at egg duration or average age of 400.63 ± 109.72 days with average value at 0.042 ± 0.004 (kg. C/ind./day) were presented in equations and also as $C\text{-emitted}_{layer} = 0.6283 (C\text{-input}_{plant}) - 0.0107$, and

$C\text{-fixed}_{layer} = 0.619 (C\text{-input}_{plant}) + 0.0003$, respectively. The carbon emission from the using of transportation energy was quite high in terms of energy using but low in the using of electricity and LPG activities. Therefore, farmers should reduce emissions from energy consumption such as reduce electricity utilization in layer farming and reduce distance for layer feed and layers transportation to farms. The using of fuel for transportation should be reduced because it creates the highest carbon emission. The result of this study also showed that the average egg weight was 62.8±4.45 g. /egg and 308.11 eggs/head at 80 weeks old of layer. The relation between the average egg weight (g.) and phase out of egg laying (weeks) was the average egg weight in gram = 5.4368Ln(phase out of egg laying in weeks)+44.935 at R^2 = 0.8388. The layer had the highest percentage of the rate of egg laying in range 84-86% at 27-28 degree Celsius. The relation between the rate of egg laying (%) and temperature (°C) was the percentage of rate of egg laying = 1.5605 (temperature in $°C)^4$-172.2(temperature in $°C)^3$+7117.6 (temperature in $°C)^2$-130611 (temperature in °C)+897897 at R^2 = 0.1631.

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