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Water footprint of chicken egg production under medium scale farming conditions of Sri Lanka: An analysis

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Abstract: Water footprint (WF) reflects how efficiently water has been utilized in the production cycle of a particular product or service. Under the production conditions of the farm of the Faculty of Agriculture, University of Ruhuna, Sri Lanka studied, the WF of Chicken Egg was calculated as 3734 m^3/ton. Other than drinking and servicing water, feed water accounted over 99% of the WF of egg production. It is concluded that through appropriate interventions, both at policy and industry level, water footprint of egg production systems can be lowered substantially.

Keywords: Water footprint, Layers, Eggs, Feed

Introduction

Water insufficiency and insecurity are among the greatest challenges caused by the climate change and global warming. Freshwater resources could be strongly affected by climate change. Increasing water scarcity and insecurity will lead to more deaths from drought and water-borne disease, political conflict over limited resources, and loss of freshwater species (Arnell, 1999) and phenomena's which associated with climate change such as more heat-waves over land areas, more frequent or intense floods, melting glaciers, higher water temperatures, increased rainfall variability are predicted to decrease equal distribution of water.

Water footprint of a product is a key criterion that reflects the water efficiency of its production. An analysis of the WF can also be used to identify the suitable strategies that can be adopted to produce a particular product at lowest WF. The objectives of this paper are 1) to determine the WF of chicken egg production under medium-scale farming conditions and production parameters of Sri Lanka and, 2) to explore the possible strategies to reduce the WF of chicken egg production. Chapagain and Hoekstra (2003) have defined the virtual-water content of a product (a commodity, good or service) as "the volume of freshwater used to produce the product, measured at the place where the product was actually produced".It refers to the sum of the water use in the various steps of the production chain. The main components of the WF were feed, drinking and servicing water. Ecological costs such CO_2emission and uses of high amount of water of livestock production systems are higher than those of crops. Some argue that consumption of livestock products should be minimized as they are hiving higher ecological cost indicators such as high WFs. However, it has been predicted that global animal product consumption including that of poultry will increase sharply in next few decades. Therefore, the means of reducing WF of animal products are of importance. WF values of range of agricultural products of different countries have been reported by Chapagain and Hoekstra, (2003) and Hoekstra and Hung, (2002). However, above calculations are based on a number of general assumptions which do not represent the actual farming conditions and production parameters. A careful analysis on how the WF value of a particular product has been computed can be used to identify appropriate strategies to reduce the WF values. Use of agricultural by-products such as rice bran, coconut poonac at higher levels was also identified as an important strategy. Policy level interventions are required to encourage ration formulators to consider water footprint values, in addition to nutrient compositions and prices of the feed in the ration formulation process.

Materials and Methods

As far as possible, the actual production conditions and parameters of the poultry unit of the Farm of the Faculty of Agriculture, University of Ruhuna were used as a model for the analysis. The methodology used by Mekonnen and Hoekstra, 2010; Champagain and Hoekstra, 2003, was used with relevant modifications. Assuming that the average egg production of a layer is 270 per year, an egg weighs about 53.75 grams, it was calculated that 73 layers are required to produce 1 Ton of eggs for an year (Table 1).

Table 1: Calculation of eggs per ton

Average egg weight per period	53.75 Grams
Eggs per ton	18604.65
Eggs per layer per year	270
Layers need to produce 1 ton of eggs	68.9037
No of layers, assuming 5% mortality	72.45

The main components of the WF were feed, drinking and servicing water. During the production cycle, six on-farm mixed rations were fed. The ingredient compositions of the rations and the main steps of WF calculation and are given in Table 2. Water Footprint values and the product fractions (PF) of the feed ingredients were collected from data bases (Mekonnen and Hoekstra, 2010). Based on the average feed intakes of layers at different stages of growth basis (0 to 4^{th}, 4^{th} to 10^{th}, 10^{th} to 17^{th} , 17^{th} to 22^{nd} , 22^{nd} to 28^{th} and 28^{th} to 52^{nd} weeks), the feed consumptions at respective periods were determined. The feed water component was the sum of water involved in the production and processing of feed ingredients and water required for feed preparation and mixing. To determine the water contribution of the feed ingredients, the WFs of each feed ingredient in the rations was multiplied by the amount of the respective ingredient, consumed. Assuming the drinking water intake of layers are as 2.5 times as total feed intake, the drinking water requirement was calculated. The servicing water component was assumed to be 50% of drinking requirement (Table 2).

Table 2. Ingredient compositions of the rations fed at different stages and the main steps of the water footprint calculation

Ingredient	Ingredient (%) for weeks of age									
	0-4	5-10	11-17	18-22	23-28	29-52	WF	PF	WF*PF*	(m^3) *
Maize meal	25	10	12	12	10	10	3203	1	3203	32.87
Rice Polish	30	38	40	40	40	40	3168	0.1	316.8	3.90
Broken rice	12	15	15	11	11	10	2497	0.15	374.55	1.84
Coconut oil meal	0	7	15	11	2	6	834	1	834	0
Gingerly oil meal	6.5	9	4	4	9	4	2847	1	2847	7.59
Soya oil meal	18	13	5	11	12	17	4851	0.85	4123.35	30.47
Fish (meal (Danish)	6	5	0	3	0	1.5	7130.97	0.85	6061.325	14.93
Fish meal (local)	0	0	5	2	5	0	7130.97	0.85	6061.325	0
Coconut Oil	0	0	0	0	0	0	4490	1	4490	0
Hypromeal	0	0	0	0	0	0			0	0
Meat and bone meal[1]	1	1.5	2	0	2	1	8974.35	0.85	7628.198	3.13
									Total	94.75
							Total			
Feed intake (kg)	41.055	138.62	237.1	269.51	327.4	1363	2377.32 kg			
Feed water (m^3)	94.75	244.66	348.1	408.18	560.49	2067	3724.10 m^3			
Total feed water									3724.10 m^3	
Feed preparation[2]									1.18 m^3	
Servicing water[3]									2.97 m^3	
Drinking water[4]									5.94 m^3	
Water foot print (m^3/ton)									3734.197m^3	

* This column gives calculation only for the period of 0-4 weeks

1. Crude protein content of meat and bone meal is 1.85 times higher than soybean meal. Since WF of fish meal is not available, WF of meat and bone meal was assumed to be 1.85 times that of soybean meal.
2. 50% of the feed consumed (Chapagain and Hoekstra, 2003)
3. 50% of the drinking water (Chapagain and Hoekstra, 2003)
4. 2.5 x feed intake (Nayanarasi and Atapattu, 2008)

WF: Water Foot Print

PF: Product Fraction

Results and Discussion

The WF of the layer egg production under the current production conditions and parameters of the poultry unit of the Farm of the Faculty of Agriculture, University of Ruhuna was calculated to be 3734.19 m^3 / ton. However, the WF value caculated was much lower than value reported by Chapagain and Hoekstra (2003); 9070 m^3/ton for the egg production in Sri Lanka. Having rice bran, broken rice, maize, soybean meal and coconut oil meal as major feed ingredients the ration used can reasonably represent a common Sri Lankan layer diet. The other production parameters were also more or less similar to typical Sri Lankan conditions. In contrast, the study of Chapagain and Hoekstra (2003) was based on a number of general assumptions. Importantly, assumption that Sri Lanka adopts a mixed system of poultry management is far from reality. Their calculations were based on a number of generalizations assuming that the farming system is a mixed one. Even though the production parameters were lower than commercial industry systems of layer chicken management, the production system of the farm studied can best be classified as an industrial system. The difference in the values reported in this study and the one reported by Chapagain and Hoekstra (2003) may mainly be due to those reasons.

The contribution of drinking and servicing water for the total WF were negligible (0.15 and 0.07% respectively). Feed water accounted over 99% of the WF of egg production and was identified as the most feasible aspect for the manipulation to reduce the WF. The contribution of each feed ingredient to the total feed water is shown in Table 3.

Ingredient	Mean % in six rations	% Contribution of the feed water
Maize meal	13.16	21.84
Rice Polish	38	8.03
Broken rice	12.33	2.64
Coconut oil meal	6.83	3.65
Gingerly oil meal	6.08	9.12
Soya oil meal	12.66	37.42
Fish (denis)	2.58	6.17
Fish meal (local)	2	5.47
Meat and bone meal	1.25	5.61

Modern layers could produce up to 360 eggs per year and thus there was a clear gap between the actual farm level feed conversion efficiency and the potential. Therefore, improvements in the management conditions towards the exploiting full genetic potentials of the birds are of importance to reduce the WF. Soya bean meal and maize meal were the highest contributors to the feed water (37 and 21%). Water efficient production systems for these crops are important to reduce the amount of total feed water.

Use agricultural by-products such as rice bran, coconut poonac at higher levels is also suggested as a strategy of lowering WF. This is mainly due to the lower product fractions of those ingredients. However, use of such materials is limited due to poor performance. Suitable strategies, such as the use of exogenous enzymes should be developed to mitigate the adverse effects of associated with higher inclusion levels of agricultural by-products on production efficiency

Policy level involvements may be needed in future so that ration formulators are required to consider water footprint values of the feeds, in addition to nutrient compositions and prices of the feed ingredients in the ration formulation process.

It is concluded that water footprint of chicken egg production under medium scale farming conditions of Sri Lanka is 3743m^3/ton. Through suitable interventions, both at policy and industry level, water footprint of egg production systems can be lowered significantly.

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