Economic evaluation of hatchery solid litter processing as poultry feedstuff supplement in Iran

S. Mashayekhi[1*] and A. Salahi[2]

[1]Research Center of Agriculture and Natural Resources of Tehran Province, Tehran, Iran.
[2]Morghdaran Tehran Company (MTC), Tehran, Iran.
*Corresponding author, E-mail address: mashayekhi2006@gmail.com

Abstract The purpose of this study was to evaluate the profitability of hatchery litter recycling into poultry feedstuff supplement. The data were collected in 2011 in 4 provinces, by direct interviewing of all hatcheries which used the hatchery litter drying machine. Net Present Value (NPV), Benefit-Cost Ratio (BCR), and Internal Rate of Return (IRR) methods were applied for this analysis. In the studied hatcheries, various methods were identified for hatchery litter handling, including municipal litter removal, drying, landfill disposal, and waste disposal well. The results indicated that only 39.1% of the hatcheries were recycling their litters; with 75% processing outside the hatchery. The average IRR of hatcheries' litter recycling was equal to 8.2%. According to the results, 22.4% of the litter processing was fixed costs, and the remaining 77.6% consisted of variable costs. It is concluded that litter recycling activity using a litter drying machine it is not economical in the studied areas based on BCR, IRR and NPV evaluation measures.

Keywords: hatchery litter, recycling, profitability analysis, poultry diet

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Introduction

The poultry industry is one of the most important agricultural sub-sectors in Iran. According to the Ministry of Agriculture of Iran, in 2009, there were 97 hatcheries in Iran, producing 181.5 million chicks (Ministry of Agriculture, 2010). On the average, 15.3 million tons of agricultural waste is produced in Iran each year, which makes up more than 17.5-18% of all agricultural products. The livestock industry produces approximately 12% of the agricultural wastes (Tutiaei and Solaimani, 2005). In developed countries, about 70% to 80% of this waste is processed, while less than 40% is processed in Iran (Tutiaei and Solaimani, 2005).

Hatchery litter disposal, an operation where most of the hatchery litter is sent to landfills or composting facilities, costs the poultry industry millions of dollars each year in Australia (Glatz et al., 2011). Hatchery litter recycling, a new technology, is a process in which hatchery litter is converted into useful materials. This has only been implemented within the last decade in Iran.

Hatchery litter consists of 35-37% dry matter (Al-Harthi et al., 2010). The major components of the hatchery solid waste include egg shells, infertile eggs, dead embryos, late hatchings and dead chickens (Glatz and Miao, 2009). In Iran**,** the hatchery waste includes egg shells after hatch, infertile eggs, cull and dead chicks, late hatchings and unhatched eggs (Koohi, 2013). The drying of hatchery litter using litter drying machines is currently the only method of hatchery waste recycling in Iran. In this method, the hatchery litter is pressed by passing through a roller, fed into the dryer tank where the temperature rises gradually until it reaches 150-170°C>After 4.5-5 hours, the hatchery litter is completely dried, and then cooled. After grinding, the product is packed and sold to broiler/layer farms and fisheries.

Feed constitutes from 60% to 70% of total cost of poultry production in Iran (Mashayekhi and Hajizadeh Fallah, 2011). Therefore, an increase in the use of cheap feed resources is an important way to increase the profitability of the poultry industry. On this basis, processed hatchery litter can be an alternative feed ingredient.

Analysis of hatchery litter showed that it consists of 22.8% (Ilian and Salman, 1986) to 37.2% (Wisman, 1964) crude protein. Furthermore, hatchery litter is a significant source of calcium from 18% (Al-Harthi et al. 2010) to 22.6% (Ilian and Salman, 1986). Studies have shown that hatchery litter can be included into the diet at a rate of 3.6% (Zohari, 1975) to 14.1% for layers (Dufloth et al., 1987), and 4% (Shahriar et al., 2008) to

5% (Wisman and Beane, 1965) for broilers. It could replace 8-16% of soybean meal without negative effects on performance in layers (Vandepopuliere et al., 1977).

From the investors' point of view, the profitability of hatchery litter recycling is uncertain, and this can contribute to a lack of interest from investors. Therefore, this study was conducted for economic evaluation of hatchery litter recycling in four provinces of Iran.

Materials and methods

The study was conducted in Alborz, Tehran, Ghazvin and Mazandaran provinces. The 64 hatcheries in these provinces constitute 66% of all hatcheries in the country (Ministry of Agriculture, 2010). The questionnaire is the principal instrument for eliciting information from the target population in a benefit-cost analysis (Chandra, 2009), which is widely used for economic evaluations in the poultry, fishery, and livestock operations. A review of existing literature revealed many empirical researches in this industry, especially in recent years, to support the selection of the questionnaire as the research tool in present study (Adesiyan et al., 2007; Al-Sharafat and Al-Fawwaz, 2013; Kawsar et al., 2013; Olaoye and Oke, 2012; Omar, 2014; Singh et al., 2010; Vukina et al., 2014).

In this study, the data were collected through completion of well-structured questionnaires by direct interviewing of all 25 chicken hatcheries in the studied area in 2011, in which the hatchery waste is processed using a litter drying machine. The questionnaire was pretested, and modified accordingly to omit the invalid questions from the questionnaire. The questionnaire consisted of a series of questions classified into three sections. The first section contained items covering socio-economic characteristics of respondents such as age, education, job experience, etc. The second section included the geographic, legal, and technical aspects of the studied hatcheries. The last section of the questionnaire was focused on the various issues related to existing costs and returns of hatchery litter recycling for economic evaluation. The executive and scientific experts' opinions were used for validity test of the questionnaire.

Reliability refers to the accuracy and precision of a measurement instrument or scale. The coefficient alpha, developed by Cronbach (1951), is the most commonly used index for estimating the reliability of measurement instruments such as scales, multiple item tests, questionnaires, or inventories (Raykov, 1997). Cronbach's alpha coefficient is given specially by:

$$\alpha = \frac{n}{n-1}\left[1 - \frac{1}{\sigma^2}\sum_{i=1}^{n}\sigma_i^2\right] \quad (1)$$

where, σ^2 is the variance of the total scores and σ^2_i is the variance of the set of 0, 1 scores representing correct and incorrect answers on item i. The theoretical range of the coefficient is 0 to 1. Suggested guidelines for interpretation are <0.6 unacceptable, 0.6- 0.65 undesirable, 0.65- 0.70 minimally acceptable, 0.70- 0.80 respectable, 0.80- 0.90 very good, and >0.9 consider shortenings the scale by reducing the number of items (Dunn, 1989). In this study, Cronbach's alpha coefficient was 0.85 indicating reliability of the questionnaire.

Benefit–cost analysis (BCA), sometimes called cost-benefit analysis (CBA), is a technique of analyzing proposed or previously enacted projects to determine whether their execution is in the public interest, or to choose between two or more mutually exclusive projects (Zerbe and Bellas, 2006). In this study, BCA was applied for the economic evaluation of hatchery litter recycling.

In hatchery litter recycling by the drying method, costs include costs of oil, fuel, power, packing, temporary staff, repair and maintenance, fire prevention, insurance, transportation, rental value of the litter recycling unit, permanent staff, business insurance, depreciation, and miscellaneous costs. The initial costs of recycling hatchery litter by using litter drying machines include land acquisition, construction of facilities, litter drying machine, and other equipment. On the other hand, benefits are the total value of processed waste in monetary terms, which are sold to the broiler farms as feed.

The timespan for hatchery litter recycling projects in Iran is considered 10 years and includes one year for start-up plus 9 years of economic life. The production of processed litter is assumed to be constant over the timespan. The investment realization (design, licensing, and construction) takes one year. The start-up phase will begin in the second year. At the end of the timespan, the operative life of the plants and other equipments is equal to the analysis period minus the construction time (European Commission, 2008). The most common indicators used in BCA are the Net Present Value (NPV), Internal Rate of Return (IRR) and Benefit-Cost Ratio (BCR) methods. It should be noted that in this study, all benefits and costs over the timespan refer to the private investors and the investment is financed by private funds. The NPV of a project is the sum of the present values of benefit minus the sum of the present values of cost (Zerbe and Bellas, 2006). It can be expressed as:

$$NPV = \sum_{t=0}^{n}\frac{B_t}{(1+r)^t} - \sum_{t=0}^{n}\frac{C_t}{(1+r)^t} = PVB - PVC \quad (2)$$

where, NPV is the net present value, n is the period for

which cash flows are expected, B_t is the benefits in year t, C_t is the costs in year t, r is the discount rate, PVB is the present value of benefits, and PVC is the present value of costs. An investment is acceptable if the NPV is positive.

A benefit-cost ratio (B/C ratio or BCR) is another important indicator in BCA. It is worked out as:

$$BCR = \frac{\sum_{t=0}^{n} \frac{B_t}{(1+r)^t}}{\sum_{t=0}^{n} \frac{C_t}{(1+r)^t}} \quad (3)$$

The definitions of B_t, C_t, n and r are the same as in expression (2). If the calculated BCR in the project is greater than one, then the project can be considered worthwhile. The internal rate of return (IRR) for a cash flow is defined as the interest rate that equates the future worth at time n or present worth at time 0 of the cash flow to zero (Bediru and Omitaomu, 2007). The internal rate of return of a project is the interest rate that will generate an NPV of zero. The decision rule is that if the IRR for a project is greater than some target rate (opportunity cost of capital), then the project is profitable (Zerbe and Bellas, 2006).

In this study, hatchery litter recycling was considered a separate economic activity regardless of whether it is done inside or outside the hatchery. All of the costs incurred and income earned from hatchery litter recycling were undertaken on an annual basis. Also, all cash inflows and outflows were considered based on one kilogram of hatchery litter processed. Meanwhile, all costs incurred and incomes earned from hatchery litter recycling were converted from Iranian Rials (IRR) into USD at a market exchange rate of 12,400 IRR/USD 2011 in order to facilitate international comparison (CBI, 2011). The operating costs were further divided into fixed and variable components. Variable costs, were those which are directly associated with the level of production and sales. Fixed costs are the costs incurred irrespective of the level of operation of a project.

In this study, the fixed costs consisted of the costs of the rental value of the litter recycling unit, permanent staffs, business insurance, depreciation, and miscellaneous costs. The rental value of land and buildings for litter recycling units were considered in place of initial investments for land and buildings even though they owned the litter processors. This was mainly due to the fact that the correct information about the purchase price of land and the construction costs of hatchery litter recycling units were not available.

The interest on both variable and fixed costs was considered as an important implicit cost in hatchery litter recycling. An implicit cost is a cost that has occurred but it is not initially shown or reported as a separate cost. In other words, implicit costs are the costs that a business incurs without actually spending money. Therefore, in this study, the interest rate on variable and fixed costs is considered as an opportunity cost incurred by firm for using variable and fixed inputs. The interest on fixed costs was calculated by multiplying the rate of interest on savings deposits in government banks of Iran during the studied period (15.5% per annum) by the sum of variable costs. The interest on variable costs was calculated by multiplying the rate of interest on short-term deposits in government banks of Iran (7.8% per annum) by the sum of fixed costs. The straight-line and declining balance methods were applied for calculation of de-

Table 1. Variable costs of hatchery's litter processing in Iran

Item	Cost (USD/ton)	% of Total Variable Cost	% of Total Cost
Fuel	13.9	9.6	7.4
Oil	7.2	5.0	3.8
Water charge	7.3	5.1	3.9
Power	5.2	3.6	2.8
Transportation	5.6	3.9	3.0
Staff	38.6	26.5	20.8
Packing	2.7	1.8	1.4
Repair and maintenance	13.6	9.4	7.3
Insurance	23.2	16.0	12.4
Cleaning and disinfecting	6.3	4.3	3.4
Communication expenses	0.6	0.4	0.3
Marketing expenses	1.0	0.7	0.5
Miscellaneous charge	9.4	6.5	5.0
Interest on variable cost	10.4	7.2	5.6
Total Variable Cost	145	100	77.6

Table 2. Fixed costs of hatchery's litter processing in Iran

Item	Cost (USD/ton)	% of Total Fixed Cost	% of Total Cost
Rental value of hatchery	14.6	34.8	7.7
Watchman	1.6	3.9	0.9
Business insurance	5.3	12.7	2.9
Depreciation expenses	13.8	32.7	7.3
Miscellaneous charge	1.0	2.5	0.6
Interest on Fixed cost	5.6	13.4	3.0
Total Fixed Cost	41.9	100	22.4

preciation of buildings and equipment, respectively. Meanwhile, land is assumed to have an unlimited useful life; therefore, land was not depreciated.

Results and Discussion

In order to evaluate the profitability of litter recycling in Iranian hatcheries, the Benefit-Cost analysis (BCA) was applied and the results are presented here. The respondents were hatchery managers. The characteristics of respondents showed that the mean, maximum, and minimum ages were 46, 66, and 33 years, respectively. The education status of respondents indicated that the majority of respondents (75%) had post-secondary education. The results also indicated that 62% of hatchery managers had more than 15 years of experience in their jobs. Although most of the responders were highly educated, 52% of them had no propensity to accept a new litter recycling method. The variable cost structure of hatcheries' litter recycling operations is presented in Table 1. Among the variable costs, expenditure on staff (26.5%) was the most significant, followed by expenditure on insurance (16%) and fuel (9.6%).

The staff cost forms a main portion of the total litter recycling costs. The calculated amount spent on staff was $38.6 USD per ton, accounting for more than a quarter of the total cost. High labor expenditure is due to the fact that hatchery litter processing is a labor intensive activity. Also, the health care of staff and the health control of hatchery litter recycling units are expensive as it requires constant disinfection. The marketing cost constitutes a low percentage of the total cost (0.5%) due to high demand for processed litter for poultry nutrition.

The fixed costs of hatcheries' litter recycling operations are presented in Table 2. Tables 1 and 2 show that 77.6% of the total cost were variable costs; the rest were fixed costs. Also, the interest on variable and fixed costs accounted for 8.6% of total costs.

The gross returns for one ton of processed litter were $110.1 USD, which is much less than its total cost. As a result, it has led to negative net returns (Table 3).

The average Internal Rate of Return (IRR) of hatcheries' litter recycling was equal to 8.2% (Table 4), which was much less than the interest rate on Savings deposits in government banks of Iran (15.5% per annum). Hence, the activity of litter recycling in hatcheries in Iran is not economically viable.

It can be concluded that this activity is not profitable taking into account all three criteria for economic evaluation, namely BCR, NPV, and IRR. It is necessary to mention that positive and negative externalities should be accounted for cost-benefit analysis. Such externalities are not captured by the financial analysis, thus need to be estimated in the economic analysis (European Commission, 2008).

This study was done from the viewpoint of hatcheries, not the society. From the social viewpoint, hatchery litter recycling has environmental and health impacts, which were not considered in this study. It is mainly due to the lack of data and research constraints. Therefore, this study cannot conclusively assert this activity as disadvantageous. If externalities and shadow prices were considered, hatchery litter recycling with negative financial NPV (FNPV) may show positive economic NPV (ENPV). Furthermore, the discount rate is also high in Iran, which directly influences the profitability of the investment projects.

Conclusions

The evaluation of hatchery litter recycling, like all economic activities, should be considered from technical, economic, financial, social, health, and environmental aspects. This study only attempted to highlight the economic aspects of this activity and based on this appraisal, hatchery litter recycling was not found to be profitable in the studied provinces. This was due to the

Table 3. Total cost and returns of hatchery's litter processing in Iran

Item	Cost or Returns (USD/ton)
Total variable cost	145
Total fixed cost	41.9
Total cost	186. 9
Gross returns	110.1
Net returns	-76.8

Table 4. Economic analysis of hatcheries' litter processing in Iran

Particular	Units	Province				Total Average
		Tehran	Alborz	Ghazvin	Mazandaran	
Present value of benefits (A)	USD/ton	112.2	109.7	100.1	124.2	110.1
Present value of costs (B)	USD/ton	188.3	185.7	187.3	183.9	186.7
Net present value (A-B)	USD/ton	-76.3	-76.3	-87.3	-59.7	-75.6
Benefit cost ratio	-	0.60	0.59	0.54	0.68	0.59
Internal rate of return	%	8.2	8.2	7.4	8.9	8.2

high cost of labor, insurance, and fuel accounting for more than 40% of total cost. Unlike many economic activities in which profitability is the most important factor, in hatchery litter recycling, health and environmental considerations may be more important than economic aspects for the society.

This study showed that hatchery litter processing should be considered as a socially responsible alternative to disposal methods, supported by the government to improve both human well-being and conservation of water and soil resources.

In further studies it may be proven that there are environmental and health benefits resulting from the recycling of hatchery litter, and also utilization of this litter as a feed supplement in the poultry industry is beneficial. Based on the insights provided by this study, the authors suggest that the government should encourage and support this activity through sufficient financial incentive policies.

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ارزیابی اقتصادی فرآوری ضایعات جامد جوجه‌کشی به عنوان مکمّل خوراک طیور در ایران

س. مشایخی و ا. صلاحی

نویسنده مسئول، پست الکترونیک: mashayekhi2006@gmail.com

چکیده هدف این پژوهش، ارزیابی سودآوری بازیافت ضایعات جوجه‌کشی به عنوان مکمّل خوراک طیور بود. داده‌ها از طریق مصاحبه حضوری از کلیّه کارخانه‌های جوجه‌کشی که دارای دستگاه خشک‌کن ضایعات جوجه‌کشی بودند، در ۴ استان در سال ۱۳۹۰ جمع‌آوری شد. روش‌های ارزش حال خالص (NPV)، نسبت فایده- هزینه (BCR) و نرخ بازدهی داخلی (IRR) برای این تجزیه و تحلیل به کار برده شد. در کارخانه‌های جوجه‌کشی مورد مطالعه، روش‌های مختلفی شامل دفع ضایعات توسّط شهرداری، خشک کردن، دفن ضایعات در زمین و چاه ضایعات جهت مدیریت ضایعات جوجه‌کشی شناسایی شد. نتایج بیانگر آن بود که تنها ۳۹/۱ درصد از کارخانه‌های جوجه‌کشی، ضایعات خود را بازیافت کرده و از این میزان، ۷۵ درصد از فرآوری، در خارج از جوجه‌کشی صورت می‌پذیرد. میانگین نرخ بازدهی داخلی بازیافت ضایعات جوجه‌کشی معادل ۸/۲ درصد بود. بر اساس نتایج، ۲۲/۴ درصد از هزینه فرآوری مربوط به هزینه‌های ثابت و ۷۷/۶ درصد مابقی، متعلّق به هزینه‌های متغیر بود. نتیجه‌گیری می‌شود که فعالیّت بازیافت ضایعات با استفاده از دستگاه خشک‌کن ضایعات بر اساس معیارهای ارزیابی BCR، IRR و NPV در مناطق مورد مطالعه، اقتصادی نمی‌باشد.