

Performance Evaluation of a Low-Cost, Energy-Efficient Automated Poultry Egg Incubator for Small-Scale Farmers of Dhalai, Tripura

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Citation: Supritam Das, Abhijit Debnath, A. K. Mohanty, Prasanta Kumar Pathak, and Bikash Deb (2024). Performance Evaluation of a Low-Cost, Energy-Efficient Automated Poultry Egg Incubator for Small-Scale Farmers of Dhalai, Tripura. *Agriculture Reviews: An International Journal*.

DOI: <https://doi.org/10.51470/AR.2024.3.1.06>

Received 11 January 2024 | Revised 09 February 2024 | Accepted 14 March 2024 | Available Online 09 April 2024

Abstract

Small-scale and backyard poultry farming plays a vital role in livelihood security and women empowerment in rural India. However, traditional egg incubation using broody hens is constrained by low capacity, inconsistent hatchability, and reduced egg-laying efficiency, while commercial incubators remain costly and energy-intensive. The present study evaluates the performance of a low-cost, energy-efficient automated poultry egg incubator developed and demonstrated by Krishi Vigyan Kendra (KVK) Dhalai at Singhinla Gram Panchayat, Tripura. The incubator was fabricated using locally available materials and low-power electronic components to maintain optimum temperature and humidity conditions. A comparative field analysis was conducted between traditional broody hen incubation and the developed incubator. Results revealed a substantial increase in hatching capacity (from 39 to 112 eggs per batch), chick production (from 355 to 994 chicks per year), and annual income (₹24,850 to ₹69,580). The benefit-cost ratio improved from 3.34:1 to 4.69:1, demonstrating superior economic feasibility. The study concludes that the low-cost incubator is a scalable, farmer-friendly technology capable of enhancing productivity, income, and sustainability of small-scale poultry farming.

Keywords: Low-cost incubator; poultry farming; hatchability; benefit-cost ratio; rural women entrepreneurship; ARYA scheme.

1. Introduction

Poultry farming is a vital component of the livestock sector in India, contributing significantly to rural employment, nutritional security, and income generation for small and marginal farmers, particularly women [1-2]. Backyard and small-scale poultry systems are widely practiced due to their low initial investment and adaptability to local conditions [3]. However, productivity in these systems largely depends on efficient egg incubation and chick availability. Traditional incubation through broody hens, though common in rural areas, is constrained by low hatching capacity, seasonal broodiness, inconsistent hatchability, and reduced egg production during the brooding period [4-5].

Commercial egg incubators offer precise control of temperature, humidity, and ventilation, resulting in improved hatchability and chick quality [6]. However, their high initial cost, continuous power requirement, and maintenance complexity limit their adoption among resource-poor farmers [7]. Several studies have emphasized the need for affordable, energy-efficient incubation technologies tailored to smallholder conditions to bridge the gap between traditional and commercial systems [8-10].

Development of low-cost automated incubators using locally available materials has been reported to improve chick output and farm profitability while ensuring ease of operation [11-12]. Dhalai designed and demonstrated a low-cost, energy-efficient automated poultry egg incubator under the ARYA scheme to enhance chick production and livelihood opportunities for rural women. The present study evaluates the technical performance and economic viability of the developed incubator under field conditions at Singhinla Gram Panchayat, Tripura.

2. Objectives

1. To design and develop a low-cost, energy-efficient automated poultry egg incubator suitable for small-scale farmers.
2. To evaluate the field performance of the incubator in terms of hatchability and chick production.
3. To compare economic returns and benefit-cost ratio between traditional broody hen incubation and the developed incubator.
4. To assess the income enhancement and livelihood impact of the technology.

3. Materials and Methods

3.1 Study Area

The study was conducted by Krishi Vigyan Kendra (KVK) Dhalai at Singhinla Gram Panchayat, Dhalai district of Tripura, India during 2023-24. The area is characterized by smallholder backyard poultry farming predominantly managed by rural women.

3.2 Description of the Low-Cost Incubator

The incubator was constructed using a 2 cm thick plyboard casing for adequate thermal insulation and durability. The overall dimensions of the incubator were 24 × 18.5 × 14.5 inches. Temperature and humidity regulation was achieved using an AROIDE W3028 / STC 3028 digital temperature-humidity controller. Two 100 W incandescent bulbs were used as heating elements, while uniform air circulation was ensured using a DHRUV-PRO 220 V AC brushless exhaust fan. Egg turning was automated at two-hour intervals using an amici Tools CN101A digital programmable timer switch.



Cost-Effective and Energy-Efficient Incubator for Small-Scale Poultry Farmer

3.3 Experimental Design and Data Collection

A comparative evaluation was conducted between traditional broody hen incubation (before intervention) and incubation using the developed mini incubator (after intervention). Parameters recorded included hatching capacity, hatchability percentage, number of eggs incubated per year, number of chicks hatched, annual income, and benefit-cost (B:C) ratio.

3.4 Economic Analysis

Economic feasibility was assessed by calculating gross returns, net returns, and benefit-cost ratio using standard farm management techniques. The B:C ratio was calculated as:

$$\text{B:C ratio} = \frac{\text{Gross return (₹)}}{\text{Total cost of incubation (₹)}}$$

4. Results and Discussion

4.1 Comparative Performance of Incubation Methods

Table 1. Performance comparison of poultry egg incubation methods

Parameter	Broody hen (Before)	Low-cost incubator (After)
Hatching capacity (eggs/batch)	39	112
Hatching capacity increase (%)	-	53
Hatchability (%)	76	74
Eggs incubated per year	468	1344
Chicks hatched per year	355	994
Annual income (₹)	24,850	69,580
Benefit-Cost ratio	3.34 : 1	4.69 : 1

The developed incubator significantly enhanced hatching capacity and chick output. Although hatchability percentage showed a marginal decline, the overall number of chicks produced increased nearly threefold due to higher incubation capacity and controlled environmental conditions. Similar observations have been reported for low-cost incubators under rural conditions [9].

4.2 Economic Viability and Benefit-Cost Analysis

The annual income from poultry farming increased by 180% following adoption of the incubator. The improvement in B:C ratio from 3.34:1 to 4.69:1 clearly indicates superior profitability. Reduced opportunity cost of broody hens, higher batch capacity, and low electricity consumption contributed to improved economic efficiency. These findings corroborate earlier reports emphasizing the role of low-cost incubation technologies in enhancing rural poultry enterprise profitability [6].

4.3 Livelihood and Institutional Impact

The findings of the present study clearly indicate that adoption of the low-cost automated incubator significantly enhanced both technical efficiency and economic returns in small-scale poultry farming. The substantial increase in hatching capacity and chick output is consistent with earlier studies reporting that controlled incubation environments improve overall productivity despite marginal variations in hatchability percentage [5]. Similar evaluations of low-cost incubators under rural conditions have demonstrated that higher batch capacity and uniform thermal regulation compensate for minor reductions in hatchability, ultimately resulting in higher net chick production [7-9].

The improvement in benefit-cost ratio observed in this study aligns with findings reported by [2-3], who emphasized that technological interventions in backyard poultry systems significantly enhance income and livelihood security, particularly for women farmers. Reduced dependence on broody hens also minimizes opportunity costs associated with lost egg production during brooding periods, a constraint widely documented in traditional poultry systems [6]. Furthermore, the use of locally available materials and low-energy components contributed to lower operational costs, reinforcing the economic sustainability of the intervention [5].

The socio-economic impact observed in the present study is in agreement with extension-oriented research highlighting the role of affordable poultry technologies in promoting rural entrepreneurship and employment generation [10-11]. The institutional support received for scaling up the technology under the ARYA scheme further validates its practical relevance and replicability in similar agro-ecological and socio-economic settings.

5. Conclusion

The study demonstrates that the low-cost, energy-efficient automated poultry egg incubator developed by KVK Dhalai is a technically sound and economically viable alternative to traditional broody hen incubation. Significant improvements in hatching capacity, chick production, income, and benefit-cost ratio were recorded under field conditions. The use of locally available materials, low-power components, and automated control systems makes the technology suitable for widespread adoption by small-scale and backyard poultry farmers. The incubator holds strong potential for promoting sustainable poultry farming, women empowerment, and rural entrepreneurship, particularly in resource-poor and off-grid regions.

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