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Design and Development of a Poultry Litter Raking Machine for Small Farms

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Authors' contributions

This work was carried out in collaboration among all authors. All authors read and approved the final manuscript.

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ABSTRACT

Poultry industries are one of the profitable agro-industries that can effectively tackle the growth of the economic sector. One of the more promising sources of biomass is poultry manure, which has the potential to be utilised as a green substitute for fossil fuels as well as a natural fertiliser and fuel for the production of biogas. The present paper discusses the developmental process of a new machine for poultry farms. The new machine can be used to rake the poultry litter on the floor bed of poultry farms at periodic intervals with ease of use and minimum disturbance to birds. The device or machine or arrangement, or apparatus can be used on poultry farms of all sizes under all seasons by people of all age groups. The paper also represents the steps followed in the identification of the need for the machine to the final level of commercialisation of the innovation. Experimentation has been carried out to compare the raking process both manually and using a litter raking machine.

Keywords: *Poultry; litter raking; machine; mechanisation.*

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1. INTRODUCTION

One of the biggest emerging industries in the nation is poultry. Nowadays, this poultry has evolved into a formalised industry and has a significant economic value at the national level. In the present scenario, poultry farm productivity has shown a gradual increase in trends due to effective management techniques [1]. To automate poultry farming, smart management techniques utilising a variety of technologically based methods are crucial [2]. Therefore farmers should adopt the most recent mechanisation for various poultry practices. It will be more advance and efficient, reduce labour costs, provide more care and take up less time and will lead to a better growth rate for the country [3].

Poultry refers to domesticated birds which are reared for human consumption [4]. Poultry litter is one of the major components of poultry farming. It is a mixture of poultry excreta, feathers, spilled feed and certain other bedding material used for poultry operations [5]. In many locations poultry litter is produced in large quantities especially in southernmost areas of Kerala [6]. In structures where broilers, turkeys and other birds are raised, the management of poultry litter needs special attention. The sawdust and coir pith waste are spread as litter materials on the floor to absorb excess moisture and also to have a smooth base.

Bird productivity is impacted by litter conditions, which in turn affects the growth and integrator earnings [7]. Additionally, litter management is required to prevent too dry and dusty environments, which have been linked to inflammation, chicken respiratory illnesses, and decreased body weight gain and certain other diseases [8,9,10]. So in order to get cure from this, the litter materials have to be turned on a day-to-day basis to enhance the bird's health and avoid smell and disease development. Successful litter management requires taking into account a variety of factors, including the season, depth of the litter, floor space per bird, feeding procedures, disease, the type of floor, ventilation, watering devices, litter amendments and even the potential value of the litter as fertiliser once it has been removed from the home [11].

In poultry farms, litter raking is done manually and takes one labour for every 5000 birds for the entire growing season. The problem with manual litter raking is improper mixing and powdering.

Hence, mechanisation in this area is an urgent need to overcome several obstacles currently being experienced. The present paper discusses the process of development of a machine for poultry litter raking. It will cover the steps followed in the identification of the need for the machine to the final level of commercialisation of the innovation.

2. METHODOLOGY

The study adopts a case study approach in the development of the new machine. Here a farm innovator interested in developing such a machine was identified. The innovator received National level third prize in Binnenal Competition of National Innovation Foundation (NIF) and owns a poultry farm of 3000 birds. He also has a start-up registered in the area of farm machinery development. Besides this, he also runs an engineering workshop concentrating on the area of research and development.

The constitution of the research team was the second step followed. The research team comprises a person from an engineering background with expertise in design software. To undertake a field study, a person from a farm extension background was also included. Further, the funding of the project was channelised through the RKVY-RAFTAAR Agri-Business Incubator of Kerala Agricultural University.

The need and design specification of the machine was identified through a brainstorming session. A total of 30 poultry farmers were made as a part of the discussion. These farmers were rearing between 1000-10,000 poultry birds.

3. RESULTS AND DISCUSSION

3.1 Need for the Machine

In the majority of poultry farms, saw dust, coir pith, husk and cereal straw are used as bedding materials on the floor of the farm to absorb excess moisture and to have a smooth floor area. The poultry litter consists of the solids excreted by birds, feathers, spilled feed and bedding materials. To limit the manure build-up, promote bird health, reduce the smell and control the disease spread among its inhabitants it is essential to do the periodic raking and redistribution of litter in the poultry houses.

Even though certain research and developments are on in this field and several prior art machines

are known. However, these prior art machines need complex machine parts and highly skilled labour rendering them very expensive and not user-friendly. Many known machines are specially designed for large-scale poultry farms and need the extensive involvement of tractors. It is also known that such a machine can have a prime mover adapted to move in one direction, which has an attachment to pick up litter from the bed. However, this device can only be used to remove the poultry litter at the end of the growing cycle. Here the poultry litter reconditioning is not possible. Moreover, the machine is viable only for large-scale poultry farms.

The present invention sorts to improve upon the above shortcomings by providing a poultry litter raking machine which is user-friendly. This litter raking machine can be used to rake the poultry droppings and litter on the floor bed of poultry farms at periodic intervals with minimum disturbance to birds. It should be adaptable for small farms.

3.2 Design Specification for the Machine

Through a brainstorming session, the design criteria identified for the machine are listed below:

- 1) The machine should be a rolling type with wheels for easy operations
- 2) The litter material shouldn't be powdered; it just needs to be properly turned down

- 3) The machine should have sufficient coverage length
- 4) The litter material should not stick to the blade of the machine
- 5) The machine should not damage the floor of the poultry shed
- 6) It should be easily operated even by a female member or a child
- 7) The machine should have both forward and reverse motion
- 8) It should work in electric power available in poultry sheds
- 9) The electric wire used for the connection should not get coiled inside the machine
- 10) Sufficient insulation should be provided to avoid electrical shock
- 11) The machine should not create much sound that can cause disturbance to the birds
- 12) The machine should be easily transported from one shed to another

3.3 The Developmental Process of the Machine

The prototype of the machine was developed by the trial and error method. The rough engineering drawings of the machine were developed by the research team, taking into consideration the design specifications. Hereafter, the fabrication of the machine was done at the workshop of the innovator. The critical problem faced during design is the sticking of the litter to the wheels of the machine. Critical changes were made to the wheels to overcome the problem.

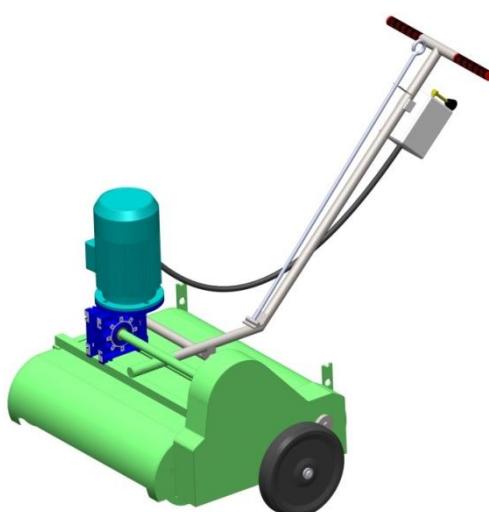


Fig. 1. Poultry litter raking machine



Fig. 2. Raking of litter using poultry litter raking machine

Similarly, the height of the wheel to the floor was also adjusted to have uniform coverage depth. The prototype machine thus designed was tested in the poultry farm of the innovator for three years (12 growing cycles). After every year, necessary modifications were made to the design to arrive at the final prototype.

3.4 Technical Specifications of the Machine

The poultry litter raking machine discussed herein has powered wheels and is designed to rake the litter on the floor bed of the poultry house. The machine will rake the poultry litter thoroughly and evenly spread it on the floor bed. It consists of an electrically powered motor that generates the necessary power for the forward motion of wheels and raking of the litter bed. It consists of a worm gearbox and a series of sprocket and chain mechanisms to transmit the power from the motor to the wheels and raking mechanism.

It has two wheel axles, with two wheels each. The wheels axles are powered from the power transmission shaft through a sprocket and chain mechanism. The tension in the sprocket and chain mechanism is adjusted by a chain tensioner. The two raking blades are fixed on two raking shafts. The raking blade consists of three sets of V-shaped blades arranged around the shaft at equal intervals. The raking shafts are powered from the power transmission shafts through a sprocket and chain mechanism. A

chain tensioner is also provided to adjust the tension in the sprocket and chain mechanism.

The raking mechanism and the forward and reverse motion of the device are activated through an electrical switch. It can traverse in both forward and backward directions. The height of the wheel can be adjusted, thereby the effective depth at which the raking action takes place, using a slotted hole in the wheel shaft bearing flange. The device is controlled through electrical switches for switching on/off and for forward and reversing movement. The device moves forward and backwards at the normal walking speed of a human, for example, 5 km/hr. For transportation of the device outside the poultry farm, two wheels are provided on a rotatable link. The link is rotated to align the transport wheels to the centre of the device while transporting. Rotatable wire support routes the electric wire away from the device while traversing forward and backwards.

3.5 Field Testing of the Machine

The field testing using the poultry litter raking machine was done in 10 poultry farms. The machine was given to the owner for one rearing cycle (45 days). The poultry farmers who were rearing around 5,000 birds were selected. The owner of the poultry farm is asked to rake the litter every alternate day with the machine. Thereafter, they were asked to compare the performance of the machine with the manual raking. The results of the experiment are given below in the following table:

Table 1. Comparison of poultry litter raking with and without using a machine

Sl. No	Items to be noted	TO 1: Raking with a spade	TO 2: Raking with machine
1	Time:- Average time taken for raking in poultry sheds with 5000 birds on a day in minutes	480	60
2	Cost:- Average labour cost for raking in poultry sheds with 5000 birds in rupees for a growing cycle (Calculated at the rate Rs/-700 per labour per day, 20 raking days)	14,000	1750
3	Quality:- Ease and quality of raking as ranked by the poultry farmer out of a score of 10	6	8

Table 2. Analysis of design specification after the development of the machine

Sl. No	Statements	Rank
1	Proper turning of the litter material	1
2	The litter material is not sticking to the blade of the machine	2
3	It can be easily operated even by a female member or a child	3
4	Less sound is produced while working	4
5	The machine provides sufficient coverage length	5
6	Easy operation on the farm due to the presence of wheels	6
7	Not creating any damage to the floor of the farm	7
8	Consuming less electric power	8
9	Both reverse and forward motion is possible	9
10	Easy transportation between poultry sheds	10

The above Table 1 shows a clear comparison of poultry litter raking with and without using the machine. First, the average time taken for raking was observed, and the result showed that the time taken by using the litter raking machine was less. In the second session, the average cost for raking was noted, and the result showed that it is very cost-effective. In the third session, the ease and quality of the raking machine were scored, and the result indicates that the scoring is maximum for the raking machine.

Hereafter, the machine was demonstrated before a group of 30 poultry farmers. Using the Garret ranking method, the design specification for the development of the machine was further reviewed and then ranked [12]. The Garret ranking was calculated using the following formula:-

$$\text{Percent position} = \frac{100(R_{ij} - 0.5)}{N_j}$$

Here, R_{ij} is the rank for i^{th} constraint experienced by the j^{th} individual

N_j is the number of constraints ranked by the j^{th} individual

3.6 Steps for Commercialisation

Once the prototype design was completed the next effort was to develop the commercial model. At this stage, the drawings of the machine were reworked material analysis was done. The cost of production was calculated and compared with similar products in the market. Considering the time, energy and materials spent in the developmental process, the final sale price of the machine was fixed. The filing of intellectual property rights was also done.

Developing linkages with the marketing agencies was the next step followed. Short videos and posters were prepared and circulated through social media. Linkage was also established with the poultry chick supplying agencies engaged in contract farming to popularise the technology. The user feedback was recorded and circulated to generate a better perception among the end users about the machine.

4. CONCLUSION

The poultry litter raking machine is technically very effective and has a very simple construction. It is cost-effective and lightweight that can be operated easily to cut and remove poultry droppings and litter very effectively from the farm bed. It can be operated at periodic intervals in a simple and effective manner, with ease of use, causing minimum disturbance to the birds. Furthermore, the machine, according to the present invention, can effectively operate in large, medium as well as small-scale poultry farms. Furthermore, the machine does away with the requirement for the involvement of heavy/skilled manual labour. The machine, according to the present invention, requires minimum intervention and can be operated by a layman.

COMPETING INTERESTS

Authors have declared that no competing interests exist.

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