INVENTORY MODEL ON ORGANIC POULTRY FARMING

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ABSTRACT

Most of the inventory models in the literature deals with manufacturing products that remains unchanged during the storage period. This study describes an inventory model for growing items (Example: chickens,hens,turkeys,farm animals etc.). Analysing the last few years poultry industry has recorded amazing and interesting growth with changes to meet the increasing demand for inexpensive and safe supply of poultry products. Appropriate management secures cost-effective production and good quality products. Therefore, research in commercial poultry production must receive a boost to keep pace with the ever-increasing demand for poultry products. A mathematical model with shortage in growing items is proposed to find the optimal order quantity and maximization of the profit. Due to the increased health awareness and customer preferences, Eco friendly poultry production is emphasized. A numerical example is presented in a specific type of poultry (Broiler) to illustrate the model.

Keywords: Poultry, Inventory model, Organic, Growth function, Broiler

INTRODUCTION

Poultry farming occupies a vital place in the economy of a country. As the human population increases, the poultry industry continues to grow to meet the demand for meat and eggs. The significance of poultry farms lies in the quality of products that are provided to humans. Some of the important factors that are responsible for successful poultry keeping are: selection of proper site and breed, economical housing, feeding poultry, controlling of diseases and parasites, proper handling of wastes, appropriate sanitizing of the poultry house and better marketing facilities. Poultry meat is an essential source of high quality proteins, minerals and vitamins to balance the human diet. Especially broiler farms provide meat that supplies the human body with high quality proteins. Poultry meat must be sound, healthy, clean and soft for human consumption. Natural growth promoters became a convincing option to substitute the antibiotic usage. Taking environmental issues into account in all management strategies at the farm level can reduce the impacts felt at the level of production.The chief poultry products are eggs and meat in addition to by-products such as feathers,manure,etc. Nowadays customers are becoming more aware of safety and quality of food products consumed by them. Hence, organic poultry farming has gained attention.

The economic order quantity (EOQ) model of (Harris, 1913) [11] is the foundation of recent inventory models. Following this model, many researchers, have contributed to the development of EOQ model. The EOQ model with the addition of shortage cost was developed by (Cárdenas-Barron,

2001) [4]. EOQ/EPQ models for perishable products such as food, vegetables, milk are also proposed ([15], [16]).Various inventory models have been developed in recent years. In 2014 Jafar Rezaei [18] provided an inventory model for growing items. Distinct from the literature, this paper exhibits an inventory model for growing items with shortages especially concentrating on organic poultry farming. Various costs regarding organic poultry farming and environmental issues are added to reflect the realistic-market behavior.

The paper is organized as follows: Section 1.1 discusses the concepts of poultry farming with their environmental issues and control measures; Section1.2 elucidates about organic poultry farming and its benefits; Section 2 comprises the mathematical formulation of the inventory model for growing items with shortages and the inclusion of various costs; Section 3 presents a numerical example in case of male broiler and Section 4 concludes the proposed work.

1.1 POULTRY FARMING

Poultry farms are farms that raise chickens, ducks, turkeys, geese and other birds for meat or egg production. India and some neighboring countries are the original homes of the well-known red jungle fowl, Gallus Gallus (Linn.), which is the ancestor of the present-day poultry breeds of the world. A better understanding of husbandry practices, and use of new technologies will make the poultry farms as a profitable enterprise. Each operation in the poultry business has become a huge business by itself. Feeding costs have a major impact on the profitability of poultry farm operations. Efficiency in the utilization of feeds is important in economically raising the birds. Using Natural growth promoter reduces the antibiotic overuse. Natural products of plant origin like spices, herbs and many plant extracts can be considered as an alternative to antibiotics as growth promoters in improving broiler performance [1]. Poultry litter can also be considered to be a by-product with economic potential. Poultry manure is of high fertilizer value which can be used for increasing yield of all crops. Controlling diseases from the beginning is important for the success of the operation Vaccination is an effective way to reduce the negative effects of diseases that can cause losses in a poultry operation [14]. Considerable quantities of poultry meat can be canned, ie., The meat gets sterilized and protected by a biodegradable pack container as it can be preserved for long periods.Packaged chicken meat is then stored in refrigerators before going to the market. After poultry is removed from the poultry house, it must be cleaned and sanitized.

Broiler industry is one of the profitable agro-industries, particularly in the rural areas. Chickens raised for eggs are called as <u>layers</u> and chickens raised for meat are called <u>broilers</u>. The slaughter age of contemporary broiler chickens is reduced to 42 days and slaughter weight exceeds 2 kg [8]. In India, the production of broilers increased from 1.89 lakh tones in 1989-90 to 23.13 lakh tones in 2009-10, at a compound annual growth rate of 13.21 per cent. In broiler production, India stands 5th in the world with 2.31 million tones of broiler meat, contributing Rs 9000 crore to the national economy [3]. Some of the common poultry diseases are: bacterial disease-the mortality rate is as high as 50 percent, Fowl cholera -the mortality rate is up to 90 percent,Infectious coryza-the mortality rate is not high,Viral diseases –unlike other diseases, there is hardly any cure for the affected birds and the only means of checking the disease are to take proper preventive measures, the mortality rate may be cent percent.(Newcastle disease), Fowl pox - the mortality rate is upto 50 percent.[17] We can prevent and control diseases by implementing biosecurity,Vaccination program and Medication but Prevention is always cheaper than cure. Biosecurity plan is a set of practices designed to prevent the entry and spread of infectious diseases into and from a poultry farm.

Environmental issues

Local disturbances (e.g. odour, flies and rodents) and landscape degradation are the usual troubles in the environs of poultry farms. Pollution of soil and water with nutrients, pathogens and heavy metals is usually caused by poor manure-management. The most important environmental issue is regarding the slaughterhouse. Various operations in the slaughterhouse discharge wastewater into the surroundings and release greenhouse gases such as carbon dioxide, nitrous oxide etc.Water pollution is majorly caused by pesticides used to control pests (e.g. parasites and disease vectors) in the poultry farm .Improper disposal of poultry carcasses may play a part with water-quality problems. Like many other food-processing activities, the necessity for hygiene and quality control in meat processing results in high water usage. This consequence in high levels of wastewater generation, having high biochemical and chemical oxygen demand (BOD and COD) due to the presence of organic materials such as blood, fat, flesh, and excreta which in turn may lead to reduced levels of activity or even death of aquatic life. Also, processing the wastewater possibly contains high levels of nitrogen and phosphorus which may cause eutrophication of the affected water bodies [12].

Most of the environmental issues mentioned above can be solved by proper hygienic management of the poultry farm. Odour emissions can be controlled by minimizing the surface of manure in contact with air. Storing poultry manure in closed buildings reduces the emissions of gaseous compounds to the air and the risk of environmental contagion as compared to the risk associated with leaving manure exposed. The three wastes of primary concern in poultry production are the litter associated primarily with broiler production, the manure resulting from laying hens & other operations and dead birds. A sensible with the hygienic system for disposing of dead poultry will help you prevent the spread of disease, prevent odours and fly breeding. Most provincial regulations require that dead poultry be disposed of within 48 hours. There are four disposal methods available to consider [20]:

- Incineration
- Rendering
- Composting
- Burial on the farm

Increase in technical efficiency and the use of new strategies at the farm are two vital components in maximizing the margin. Sex-separate feeding and maintaining optimum grow-out period of birds are two strategies that farmers can easily apply to increase the profitability of the farm. The level of environmental impacts is highly dependent on production practices and especially on manure management practices.

1.2 Organic Poultry farming

As resource depletion and unsustainable short term growth are very real threats to our future on the planet people are becoming more environmentally conscious than ever before. Therefore Organic farming gains much attention. Organic poultry farming is a way of growing food in harmony with nature.Organic poultry seeks to produce healthy, good quality poultry products in an ecologically responsible way, for which the producer gets a fair return. The system is designed to avoid the need for agrochemicals and to minimize damage to the environment and wildlife. If meat is to be marketed as organic the birds must be slaughtered and processed by operators who are registered with an organic inspection body and subject to an annual inspection process. There is a strong demand for organically reared table birds, provided that they are of good conformation and quality. It is of interest to note that organic chicken is 20% higher priced than conventional. Organic farming does not require any external inputs (i.e. fertilizer, antibiotics etc.). The main objective to follow organic housing and management standards is to provide an opportunity for poultry bird to reveal all its normal behavior patterns. This will be helpful to minimize the stress to the birds. For organic poultry production birds should not be caged and reared under the deep litter system. The birds should be fed 100% organically grown feed of good quality. All ingredients must be certified as organic, except vitamin and mineral supplements, making up to 5% of the diet. The largest component of any organic poultry diet is the cereal (maize). Home grown protein sources like peas, beans and rape seed can be utilized. No debeaking for pecking. Use of natural medicines and methods, including Homeopathy and Ayurvedic should be stressed. Lack of in-depth knowledge about organic poultry farming on the part of poultry farmers and awareness among consumers is a barrier in both at the production and marketing level. However, before you enter conversion to organic poultry farming , it is essential to explore and secure the market.

2. Formulation of mathematical model

Assume that a company buys newborn birds (e.g. Broiler), grows them, slaughters, packs and sells them to the market. The objective is to determine the optimal quantity of one day chicks to be purchased and with this we can find the maximum total profit. The following notations and assumptions are used throughout to develop the EOQ model.

2.1 Assumptions

1. Let y be the number of newborn animals the company orders from the supplier at each growing cycle, and w_0 and w_1 the initial weight (the weight of newborn animals) and the final weight (the weight of slaughtered animals), respectively.
2. The total revenue is the sum of total sales of the slaughtered animals and total sales of by-products (C_B)such as feathers,manure,etc.
3. The slaughtered animals are then gradually sold at demand rate d
4. Shortages are allowed
5. The production (feeding) costs vary over time as the new born birds grows. Assume the total feeding costs as $c_f y\int_0^{t1} f(t)dt$ where t_1 is the length of the growing cycle.
6. In the existing literature, several mathematical models have been used to measure poultry growth (e.g. Gompertz, 1825; Richards, 1959). One of the most commonly used models is that of Richards (1959), which is a nonlinear model, as follows: $w_t = A\left(1+be^{-k_0 t}\right)^{-1/n}$ ----(1) is considered in this paper. Where w_t is the weight of bird at time t; A is the asymptotic weight as age approaches infinity (an estimation of mature weight); k_0 is the rate constant or growth rate, which determines the spread of the curve along the time axis; n is the shape parameter which determines the position of the inflection point; b is the integration constant.
7. For the production (feeding) function, we use the polynomial function $f(t)$ which relates feed consumption to the age of the chicken (Goliomytis et al., 2003), as: $f(t) = \mathrm{b}_0 + \mathrm{b}_1\mathrm{t} + \mathrm{b}_2\mathrm{t}^2 + \mathrm{b}_3\mathrm{t}^3$----(2)
8. Organic poultry farming procedures are followed. After slaughtering the items are packed in a bio-degradable materials including natural preservatives and then transported with refrigeration facilities.

2.2 Notations

y - number of ordered items

w_t -weight of unit item at time t
p -purchasing price per weight unit
s -selling price per weight unit
c_f -feeding cost per unit item
h -annual holding cost per weight unit
K -setup cost per growingcycle
Q_t -total weight of inventory at time t
d -annual demand rate
A -asymptotic weight
k_0 -growth rate
n -shape parameter of the growth function
b -integration constant of the growth function
N -Natural growth promoter cost per unit item
S_1 -Maximum shortage per order
C_S -Shortage cost per unit per time period
P -Cost of materials used for packaging per parcel including natural preservatives(Example : Bisin)
L -Labour cost for slaughtering and packing per parcel
m -Number of parcels
a -fixed cost per trip
b_t -Variable cost per unit transported per distance travelled
d_1 -distance travelled
R -refrigeration cost during transportation
γ_0 -fixed cost per waste disposal activity
γ -cost to dispose waste to environment
θ -proportion of waste disposal per cycle
E_m -Cost to control the emissions of Co_2,No_2 etc.
C_l -Slaughter house cleaning cost per unit area
P_o -Pollution control cost

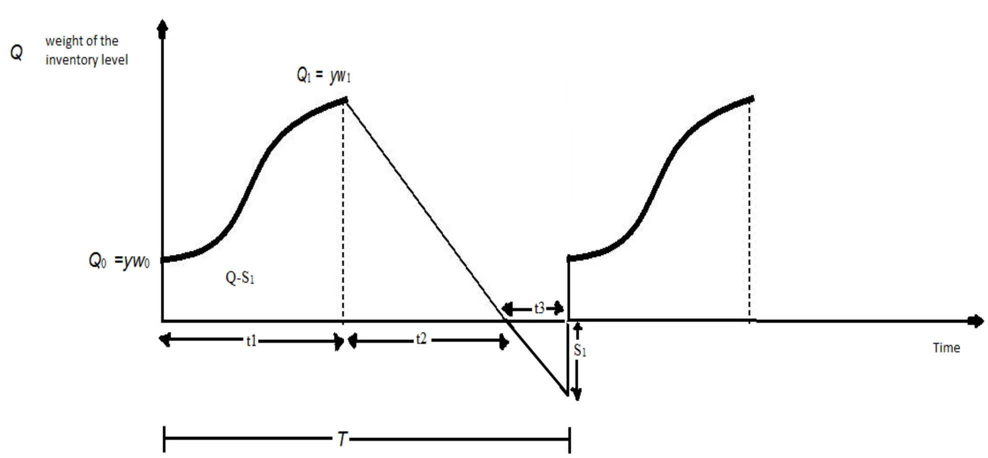

Figure 1 . Behaviour of growing items with shortages over time

Total profit = Total revenue – Total costs
= Total revenue – (Purchasing costs + Production costs + Holding costs + Setup costs + Shortage costs + Packaging costs + Transportation cost + Disposal costs + Environmental costs)

The total profit function per cycle would be:

$$TP = syw_1 + C_B - \left[\begin{array}{l} pyw_0 + c_f y \int_0^{t1} f(t)dt + Ny + \frac{h\left(yw_1 - s_1\right)^2}{2d} + k + \frac{s_1^2 (c_s)}{2d} + (p+L)m \\ +2a + R + b_t d_1 y + \gamma_0 + \gamma y \theta + E_m + C_l + P_o \end{array} \right] \text{----- (3)}$$

The total profit function per unit time is obtained as

$TPU = \dfrac{TP}{T}$ where $T=t_1+t_2+t_3 = yw_1/d$

$$TPU = = \frac{d}{w_1} \left(\begin{array}{l} syw_1 + C_B - pyw_0 - c_f y \int_0^{t1} f(t)dt - Ny - \frac{h\left(yw_1 - s_1\right)^2}{2d} - k - \frac{s_1^2 (c_s)}{2d} - (p+L)m \\ -2a - R - b_t d_1 y - \gamma_0 - \gamma y \theta - E_m - C_l - P_o \end{array} \right)$$

After substituting the appropriate functions(1)&(2) and arranging the terms we get

$$TPU = sd + \frac{C_B d}{yw_1} - \left[\begin{array}{l} \frac{pdw_0}{w_1} + \frac{c_f d \int_0^{t1} f(t)dt}{w_1} + \frac{(N + b_t d_1 + \gamma\theta)d}{w_1} + \frac{h\left(yw_1 - s_1\right)^2 + s_1^2 (c_s)}{2yw_1} + \\ \frac{d(k + (p+L)m + 2a + R + \gamma_0 + + E_m + C_l + P_o)}{yw_1} \end{array} \right] \text{----(4)}$$

$$TPU = sd + \frac{C_B d}{yA\left(1+be^{-kt}\right)^{-1/n}} - \left[\begin{array}{l} \frac{pdw_0}{A\left(1+be^{-kt}\right)^{-1/n}} + \frac{c_f d \int_0^{t1} b_0 + b_1 t + b_2 t^2 + b_3 t^3 \, dt}{A\left(1+be^{-kt}\right)^{-1/n}} + \frac{h\left(y(A\left(1+be^{-kt}\right)^{-1/n}) - s_1\right)^2 + s_1^2 (c_s)}{2yA\left(1+be^{-kt}\right)^{-1/n}} + \\ \frac{d(k + (p+L)m + 2a + R + \gamma_0 + + E_m + C_l + P_o)}{yA\left(1+be^{-kt}\right)^{-1/n}} + \frac{(N + b_t d_1 + \gamma\theta)d}{A\left(1+be^{-kt}\right)^{-1/n}} \end{array} \right]$$

---- (5)

To derive the optimal solution, let us take the first derivative of TPU with respect to y and equate it to zero. That is,

$$\frac{\partial TPU}{\partial y} = -\frac{hw_1}{2} + \frac{hs_1^2 + s_1^2 c_s}{2y^2 w_1} + \frac{d\lambda}{y^2 w_1}$$

where

$$\lambda = k + (p+L)m + 2a + R + \gamma_0 + + E_m + C_l + P_o - C_B$$

We get the optimal order quantity as

$$y^* = \sqrt{\frac{hs_1^{\,2} + s_1^{\,2}c_s + 2d\lambda}{h(A^2\left(1+be^{-kt}\right)^{-2/n})}} \text{ ------(6)}$$

3. Numerical example

This numerical example is for a specific type of poultry: Male broiler chickens.

Male broilers generally grow faster and consume more feed than female .Assume the parameters with the following data.

w_0	- 40 g	R	- Rs.4/period
p	- Rs.0.56/g	γ_0	- Rs.1/unit
s	- Rs.0.11/g	γ	- Rs.0.2/cycle
c_f	- Rs.0.067/g	θ	- 0.003
h	- Rs.0.01/year	E_m	- Rs.0.95/cycle
K	- Rs.2,12,767.03/cycle	C_l	-Rs. 0.29/cycle
d	- 3,0000000g/year	P_o	- Rs.0.34/cycle
A	- 6870.2	d_1	- 250 km
K_0	- 0.036	P	-Rs. 2/unit
n	-0.0087	L	- Rs.1.21/unit
b	-0.043	m	- 20/cycle
w_t	-2195 g	a	- Rs.5/trip
s_1	- 150 g/unit	b_t	- Rs.0.01/unit/km
C_S	- Rs.0.001/unit	t	-42
N	- 0.92/g		

We have the optimal order quantity as,

$$y^* = \sqrt{\frac{hs_1^{\,2} + s_1^{\,2}c_s + 2d\lambda}{h(A^2\left(1+be^{-kt}\right)^{-2/n})}}$$

On substituting the numerical values we get **y*=13883** items

The total profit is obtained using the expression

$$TPU = sd + \frac{C_B d}{yw_1} - \left[\frac{pdw_0}{w_1} + \frac{c_f d\int_0^{t1} f(t)dt}{w_1} + \frac{(N + b_t d_1 + \gamma\theta)d}{w_1} + \frac{h\left(yw_1 - s_1\right)^2 + s_1^{\,2}(c_s)}{2yw_1} + \frac{d(k + \left(p+L\right)m + 2a + R + \gamma_0 + + E_m + C_l + P_o)}{yw_1} \right]$$

TPU = Rs.11,20,420.39

Case(i): Disease Prevention Act

Usually the chicken in the broiler farm gets affected by the diseases.It creates a major impact in the profit of the farm. As Prevention is always cheaper than cure ,we include two costs in the conventional model formulate above.They are:

Regular or periodic vaccination cost + Medication cost at affected time

After adding these two prevention act, the mortality rate will be much reduced even though there is a seasonal disease attack.Hence now the total profit will be

TPU = 1120420.39-13450-28204

= Rs.1078766.39

Case (ii): Seasonal disease affected without prevention act

The mortality rate is very high when the seasonal disease affects the poultry farm without the vaccination procedure.The owner will be majorly affected regarding the financial position. At the disease affected time , we can just provide some medical facilities.Considering this in the conventional model we add the following costs.

Medication cost + Loss of chickens about 62% averagely (Mortality rate)

8607.46 chickens will be lost and 5275.54 only remains

The disposal rate of dead chickens will be increased

Hence,θ=0.005, Cl=0.47, P_o=0.56

Now the total profit will be,

TPU = -10,90,157.218

Hence there will be loss of about Rs.10,90,157.218.

Therfore Prevention must be taken to avoid majority loss.

4.Conclusion

India has tremendous potential in organic poultry production as large parts of the country is organic by default. On the other hand the ill effects of conventional farming are compelling the consumers to shift to the organic products.In this paper, we presented a mathematical model for organic poultry farming with its associated costs.Proper management implies more profitability for firms. Since the feeding cost occupies the major part alternative and cheaper ingredients for poultry feed must be developed,preferably locally.(low cost feed supplements that are not used for human consumption).Disease prevention act in the example explicit its importance. Since prevention is the only method for protecting the birds from various viral infections,it is advisable to get the birds vaccinated against various infections at the proper age.Control can be achieved by adopting strict methods of sanitation and hygiene,avoiding overcrowding, employing better management and feeding practices,and keeping careful watch on the spread of the infection.

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