Indian J. Genet., 79(1) Suppl. 204-207 (2019)
DOI: 10.31742/IJGPB.79S.1.10

Breeding poultry for improved input use efficiency and nutrient quality of products

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(Received: January 2019; Revised: March 2019; Accepted: March 2019)

Abstract

Poultry egg and meat are the two cheapest sources of animal proteins for non-vegetarians across the globe. The improvement of poultry production needs to be efficiently carried out for which various tools are to be adopted. Simple breeding theory inculcates mating among the superiors, which is being practiced since long before. Poultry improvement has gained momentum to augment the performance of birds not only in terms of production but also sustainability. Chickens are mainly classified as egg-type chicken and meat-types chickens. Along with the major production traits, other functional traits such as feed efficiency and nutrient quality of poultry produce are being given due emphasis to achieve the major target. Many conventional selection and breeding approaches have been adopted by the animal breeders to improve these traits. Due to the inherent nature of population and selection criteria, the rate of genetic progress became relatively slow and ultimately, the variability of pure line populations has been gradually shrunken. The nutritional approach maximizes the net profit of the poultry rearing by providing suitable niche to express the desired economic traits in optimum capacity. Recently, genomic selection and biotechnological approaches are showing high potential to enhance the productivity of birds at faster rate.

Key words: Poultry, feed efficiency, nutrient efficiency, nutrient quality

Introduction

Poultry caters human food in terms of egg and meat. Human population is increasing day by day and so its requirement. People whether rich or poor, consume meat and egg to mitigate mainly the protein requirement. Currently, the poultry meat sector is one of the most intensively growing agri-food sectors. According to FAO/OECD prediction for the year 2020, poultry meat will be the most produced meat in the world reaching nearly 140 million tons of meat. When farmers started to practice breeding scientifically, they used to select elite birds on the basis of their phenotypic performance. Gradually science becomes more advanced and people used to look into the details of the phenotype so that their selection would be more precise and accurate. Thus, poultry improvement has gained momentum to augment the performance of birds not only in terms of production but also sustainability.

Many traits in these poultry breeds have been included in the selection criteria to develop newer breeds or varieties. Initially, the production traits were included in the selection programme by the Poultry Industry, but to make the poultry sector more viable/ feasible, many other traits such as feed efficiency in other word input use efficiency and value addition in the poultry produce etc. have become desired traits for the Animal Breeders. In this manuscript, we have discussed the breeding programme for improving the feed efficiency and value addition in the poultry produce.

Poultry genetic resources in India

India is the origin of jungle fowls, from which all modern domestic breeds of chicken have been developed. Indigenous breeds are well adapted to insensitive climate change and intricately associated with the culture of farming community. The indigenous breeds are important genetic resource owing to their adaptive traits and socio-cultural practices of local communities rearing them. Based on phenotypic characteristics and production performance, 19 Indian native breeds of chickenare registered. These include chicken breeds like Aseel, Ankaleshwar, Busra, BrownDesi, Chittagong, Daothagir, Denki, Ghagus, Haringhatta

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Published by the Indian Society of Genetics & Plant Breeding, A-Block, F2, First Floor, NASC Complex, IARI P.O., Pusa Campus, New Delhi 110 012; Online management by www.isgpb.org; indianjournals.com

Black, Kadaknath Kalasthi, Kashmir faverolla, Miri, Punjab Brown, Tellicherry, Nicobari,Hansli, Uttara etc.

Feed efficiency traits

Feed efficiency can be defined as the rate of converting feed consumed by the animal to the desired output such as body weight or egg production. The term 'feed efficiency' can also be called as feed conversion ratio. In American and Asian countries, the value is calculated by dividing feed intake by weight gain. In some European countries, the efficiency is calculated as weight gain divided by feed intake, and a corresponding value would be 0.53 or so. However, feed efficiency is very much useful in describing feed intake in relation to growth rate. Sometimes, feed efficiency is measured in terms of feed cost/kg weight gain or more specifically, cost/kg deboned meat as feed efficiency is the direct indicator of economics of poultry rearing.

There are many factors affecting feed intake in birds. Of which, the most important ones are energy content in diet, sex, age, environmental temperature, bird's health etc. The bird eats to its maximum physical capacity and the birds' energy intake can easily be controlled by varying the energy density in the diet. We can temper early growth rate by feeding low energy diets and as the broiler gets older, it does seem to adjust its intake in relation to diet energy level. As the birds eat more feed at constant growth rate, then feed efficiency starts to deteriorate. On the other hand, if we calculate energy efficiency, then the birds on the lower energy feed are actually the most efficient in converting feed energy to weight gain. As birds get older, their feed efficiency will deteriorate. The heavy birds use increasing quantities of feed to maintain their body mass and less is used for growth. The bird's performances are greatly influenced by the environmental temperature. After initial brooding, the bird use some of its feed to maintain its body temperature. Under ideal conditions of around 20-25 degrees Celsius, the bird uses a minimum of feed to maintain body temperature.

An unhealthy bird is likely to have poor feed efficiency because feed intake is reduced, and so again proportionally more feed is directed towards maintenance. A bird with sub-clinical coccidiosis is not likely to absorb nutrients with optimum efficiency, because the oocytes will destroy some of the cells lining the gut involved in energy absorption and metabolism. Recently, the phenomena of so-called "feed passage" has been defined in broilers. Undigested feed particles are seen in the excreta, and so consequently feed efficiency will be affected. The exact cause of this problem is unknown, but is most likely the consequences of microbial load in the birds.

Breeding for feed efficiency

As the feed efficiency of a bird is a polygenic trait controlled by many genes involved in feed digestion, absorption, metabolism, assimilation and excretion, improvement can be achieved through selection. Feed conversion ratio (FCR) is one of the most widely used measures of feed efficiency. In case of broilers, group feeding is carried out for estimating feed efficiency of birds. Sometimes, full sibs or half sib groups are formed and kept for estimating feed efficiency of a family. Accordingly, better family or groups are selected for this trait and bred among the elite groups to obtain better progenies with good feed efficiency. Thus, family selection is the choice of criteria of selection for improving feed efficiency in broiler birds.

In case of layer birds, feed efficiency is calculated in individual birds reared in the cage system of rearing. Traditionally part record selection has been advocated as a means of shortening generation interval to increase rate of genetic progress. In order to optimise genetic gain/unit of time, multi-stage selection is followed as it reduces the cost and efforts (by discarding inferior birds at early age) and generation interval is minimized. Feed conversion efficiency can be improved through selecting birds for increased egg mass and smaller body size. The most commonly used criteria for feed efficiency in laying hens are daily feed intake per hen, feed intake per egg, feed conversion (kg feed per kg egg mass) and net income from egg. From majority of the selection experiments reported in the literature and parameters estimated from large commercial populations, it is apparent that most laying hens have a remarkable ability to adjust their feed intake to requirement. In recent years, because of moderate to high heritability and absence of significant negative effect on production parameters, residual feed consumption is used as selection criteria to improve the feed efficiency.

Breeding for Residual Feed Efficiency

Residual feed intake (RFI) is defined as the difference between the measured feed intake and the expected feed intake of an animal and accounts for its maintenance requirement. The RFI in more efficient animals has a negative value which indicates lower

energy requirements than predicted. The heritability estimates of RFI is reported on the level between 0.23 to 0.49.

The biggest shift in poultry breeding have been utilization of DNA based technologies. Even though the FE was already greatly improved with the classical selection methods, the genomic selection provides possibilities for further improvement of that trait with higher (4 times) accuracy compared to the classical pedigree information. Further, the decrease in generation interval from 12 to 6 months can be expected with the application of genomic selection as breeders do not need to obtain phenotypes of all young birds. However, costs of genotyping is the limiting factor as to start implementing the technology into the breeding program it is necessary to genotype at least 3000-5000 animals in the training set (Sell-Kubiak et al. 2017).

Breeding for nutrient quality of poultry produce

Some of the important egg quality traits are albumin quality measured in terms of albumin index or Haugh unit, yolk index, egg shell thickness, egg protein content, low fat/cholesterol content in egg, mineral content etc. All these traits are polygenic traits and can be improved by appropriate selection programme.

Egg shell quality has received added emphasis as a result of changing commercial practices, with minimising cracked and broken eggs in commercial systems of egg supplying chain. There have been reports of QTL for egg shell quality traits withexistence of dense SNPs (Honkatukia et al. 2011). There was a clear evidence suggesting that selection of the hens laying eggs with the best cuticle coverage will have less bacterial penetration (Bain et al. 2009). This has important implications for consumer safety, reducing spoilage and reducing egg to egg transfer of microorganisms. Selection based on cuticle may improve the quality of eggs in terms of food safety with minimum bacterial load. Albumin index and Haugh units have relatively high heritabilities ranging between 0.2 and 0.5. However, protein content would seem to be of more practical use in the processing industry and Haugh units or albumin height has a relatively poor genetic correlation with protein content. Attempts to estimate protein content in egg has been made using near-infrared transmission spectroscopy and low resolution proton nuclear magnetic resonance (Kemps et al., 2007). Identification of suitable selection criteria and carrying out genetic selection is needed to improve the albumen quality of the egg to meet the consumer demand.The vitelline membrane is an important character of egg because of the requirement for clean separation of yolk and white while breaking eggs. Achieving a reliable and repeatable measurement for vitelline membrane strength would seem to be a useful research objective. The sensory quality of egg yolk is another target in poultry industry as egg contains some fishy smell which sometimes are not desired for the consumers. The gene responsible for this fishy smell is flavin containing mono-oxygenase isoform (FMO3). The quantity of this gene product may be minimized by adopting appropriate selection. Individual selection would be the best approach of selection as the heritability of the trait would be very high.

The fat/cholesterol content in egg and meat are the highly heritable traits. Hence, mass/individual selection can improve the birds for these traits with higher magnitude of genetic gain. Further, biotechnological approaches such as genetic marker based selection, gene silencing and genome editing through CRISPR/Cas system can reduce the cholesterol content in eggs and meat very efficiently. The genes involved in *de novo* lipid biosynthesis path way are the candidates to analyse for determination of genetic markers for the traits. The biotechnological intervention in this regard is at nascent stage and at our Institute, the research is going on in the field of gene silencing by targeting some candidate genes involved in lipid biosynthesis. The *in vitro* studies have been completed and in vivo studies are in progress to develop the gene knock down chicken for low cholesterol content in meat and eggs.

Conclusion

Poultry being the industry is exclusively involved in making it more profitable and sustainable. Alongwith the major production traits, other functional traits such as feed efficiency and nutrient quality of poultry produce are being given due emphasis to achieve the major target. Many conventional selection and breeding approaches have been adopted by the Animal breeders to improve these traits. Due to the inherent nature of population and selection criteria, the rate of genetic progress became relatively low and ultimately, the variability of pure line population has been gradually shrunken. The nutritional approach sometimes, maximizes the net profit of the poultry rearing by providing suitable niche to express the desired economic traits in optimum capacity. Further, besides traditional pedigree information based approach,

genetic selection can be considered to further speed up genetic improvement. Recently, biotechnological approaches are making efforts to enhance the productivity of birds with rapid genetic progress. But, sometimes, statutory obligations involved in these biotechnological intervention hinder the rapid augmentation process of genetic potential in animal production. However, superstition and un-scientific belief about the genetic manipulation should be wiped out to obtain the fruits of recent advancement of sciences so that the hunger may be removed from this world at a very rapid systematic ways. The entire human population in this Earth can live and survive peacefully with good health and prosperity.

Declaration

The authors declare no conflict of interest.

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