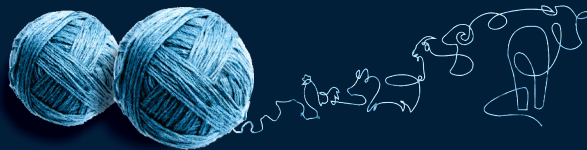


12th  
INTERNATIONAL  
SYMPOSIUM

MODERN  
TRENDS  
IN LIVESTOCK  
PRODUCTION



P R O C E E D I N G S

9 -11 October 2019, Belgrade, Serbia

# Institute for Animal Husbandry

Belgrade - Zemun, SERBIA

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## LAYING HENS MANAGEMENT AND NUTRITION FOR MAXIMAL EGG PRODUCTION AT 100 WEEKS OF AGE

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Invited paper

**Abstract:** In the third decade of the 21st century, starting from 2020, leading breeding companies promise that their modern hybrids of laying hens will be genetically able to produce 500 eggs per hen till 100 weeks of age. This paper discuss some important questions about what we need to know and practice in the management, and especially in the feeding of these highly sophisticated, extremely productive and very demanding birds to achieve that goal in near future. The management and nutrition strategies, needs and recommendations, dynamics of feeding during the day and during the production cycle are discussed. The maximum production results in line with genetic predisposition can be achieved by precision nutrition, as well as by maintaining and preserving the health of laying hens and the quality of egg shell with proper nutrients and specially formulated diets, but first with closer cooperation between breeders, nutritionists and egg producers.

**Key words:** laying hens, maximal laying capacity in one cycle, feeding technology, feeding techniques

### **Introduction**

Soon it will be possible to keep modern hybrid layers for 100 weeks, instead of 70, 80 or 90, with production of nearly 500 eggs per hen, as a result of the constant efforts primarily of the breeding companies, but also the table egg producers and the feed industry. The current management guide of the ISA Brown hybrid manufacturer state that today, in the optimal housing and nutrition conditions, we can expect 420 eggs per housed hen to the 90th week of age (*ISA, 2018*). The company's goal by 2020 is that their genetics in the extended production cycle of 100 weeks will be able to lay 500 quality eggs per housed hen. It is similar to other leading breeding companies.

Keeping of laying hens in continuous extended production up to 70-80 weeks without molting is still not a widespread practice. However, it is in the focus as the future direction of development of the breeding companies and some egg manufacturers due to potential economic and ecological benefits (*Bain et al., 2016*). On the other hand, induced molting and the second laying cycle as the standard way of extending the production life of layers is still a very common practice, for example, in the USA by estimates in about 20% to as much as 80% of table egg layers, depending on the specific year and conditions (*Flock and Anderson, 2016*). The decision whether the producer will extend the period of the flock exploitation and how depends on many factors, primarily those of production and economic nature.

Genetic progress and a longer production cycle are necessarily accompanied by changes in nutrition. Layers convert nearly one-third of daily consumed nutrients into eggs almost every day, which is a major daily metabolic effort, especially for the liver, bones and reproductive organs. In order to be able to adopt, metabolize, and then excrete large quantities of nutrients in a laid egg, hybrid layers require appropriate nutrition technology and precise daily satisfaction of feed requirements throughout the entire production cycle, where optimal conditions and healthy animals are implied.

In order to achieve high production in an extended cycle of exploitation of laying hens, it is necessary to apply as precision and as proper nutrition as possible. Precision nutrition is way and tools how best to achieve production goals (*Lukić et al., 2016*), and the primary goal of table egg producers is to maximize the use of genetic potential of the layers at the lowest price, i.e. in terms of nutrition, less nutrients in the manure and the more in the eggs. An additional important goal in the extended production cycle is to preserve the animal health and the quality of eggs as long as possible with proper nutrition. In order to achieve this in practice, a consistent application of the existing scientific information on animal nutrition is required, with a mandatory high level of control and rapid reaction to changes, as well as close cooperation between animal breeders, nutritionists/feed producers and egg manufacturers.

This invited paper will discuss important aspects of the management, especially the nutrition of the laying hens from the beginning of the laying period to the end of the extended exploitation, assuming that the rearing and transfer of pullets (the basis on which the future good laying capacity is built) was carried out on a proper way, and consequently aware of the fact that the extended production cycle actually begins on the first day of birds life. The paper aims to contribute to solving the challenges that are expected through the broader use of longer continuous exploitation of laying hen hybrids genetically capable for this.

## **Management and nutrition strategy**

Decision whether the producer will extend the period of the flock exploitation and how depends on many factors, first of all economy ones (feed/egg price, possibility to sell spent flock and/or to buy a new one). Also, two basic production criterions that determines when to replace the (healthy) flock are reduced laying capacity and poorer quality of the eggs (especially the quality of the egg shell), which normally drops with the age of the layers (*Bain et al., 2016*). Therefore, for every successful extension of the laying cycle over 70 weeks of age, it is essential to preserve the optimum "working conditions" of all organs and tissues involved in egg production throughout the lifetime of the layer, primarily through proper management and nutrition strategy.

The basic nutrition strategic issue, whether to produce feed or partly or fully procure it on the market, is determined by the choice and capabilities of the egg producer. When choosing a feed manufacturer, in addition to the price and quality of feed as standard criteria, the scope and quality of customer support services are becoming increasingly important. The complexity and number of issues that need to be solved in the nutrition of modern layers to achieve maximum productivity justify the necessity and importance of teamwork and the need for a nutritionist in the team. Today, the basic questions of animal nutrition (what feed to use; how to feed modern animals in order to meet the needs of each individual in the flock; balance the ecosystem, producers' wishes and consumer demands) seem to be more and more difficult to find the right answers to. On the other hand, the multi-decade-long intensive development of the global feed industry, which has reached a total production of about 1 billion tons in recent years, has been successfully following the development of poultry industry by offering innovative solutions in the form of products and services (*Crots, 2016; Bradford, 2016*).

The availability of knowledge, experience, tools or services required, but first of all, willingness of the producers to change, could be a limiting factor for the wider global application of this (as well as any other) new practice. However, which management and nutrition strategy will be adopted and applied in future depends primarily on the goals and capabilities of each individual egg producer.

## **Precise and correct nutrition during (extended) laying cycle**

First of all, the most recent data on the genetic potential and specific nutritional (and other) requirements of hybrids are needed. The best breeding companies are trying to summarize the decade-long practical and research experience of work with their own genetics, as well as (now) a century long



experience of the science of animal nutrition, in these manuals for breeding and nutrition. However, since the recommendations are nevertheless general estimates and averages, for the nutrition program of a particular flock it is necessary to adjust these values and specifications in order to calculate the appropriate reduction or increase of nutritional needs based on the actual production conditions and status of the flock, especially when the goal is to achieve as long a production cycle as possible. Also, new scientific knowledge should be constantly monitored.

Nutrition programs for modern hybrid layers of table eggs during the extended production cycle determine phase nutrition, as a practical way to keep constant changes in the lifecycle and production cycle accompanied by adequate dietary changes. In the case of laying hens, we can conditionally distinguish three life and technologically important periods: rearing (growth), rearing and production (simultaneously) and production. After rearing and feeding in three phases (starter, grower and developmental mixture), ending with the pre-laying mixture, hybrid producers recommend that layers during the exploitation are fed with three, four or even five different mixtures. Therefore, in order to formulate nutrition and diets for modern layer hybrids, eight different specifications of complete mixtures (from 5-10 mixtures, depending on the recommendations of the hybrid manufacturer) usually must be prepared in practice starting from the first day of life until the end of the production cycle.

The daily intake of nutrients (g of nutrients per hen per day) must be adequate to the daily needs of the layer of a given age, in specific farming conditions and with the achieved level of production. Given that adult laying hen normally have a ability to adjust their feed intake to their needs, primarily the energy, consumption of feed of each layer can vary, and is conditioned mostly by the body weight, production and concentration of energy in the mixture, as well as ambient conditions (temperature, humidity, gases) and the status of the individual layer (health, feathering, activity), especially if they are not optimal. The quality and form of the feed for layers can also significantly affect consumption if they are not adequate, especially the quality of the raw materials used, the cellulose content and the size of the particles in the mixture. Particular attention should be paid to the beginning of laying period, from 18-25 weeks of age when the needs increase rapidly (*Rutten, 2016*), and the ability of birds to consume slowly reaches its maximum (during this period young layers increase the consumption by nearly 40%). Daily control of feed intake and laying capacity, weekly control of body weight and weight of eggs and timely and adequate correction of the mixture in this crucial period establishes the balance of consumed and needed energy and nutrients in the organism of young layers, thus providing the necessary foundation for the long lasting laying of quality eggs.

Recommendations for the energy value of mixtures for layers are the starting point in the formulation of the diet because the adult poultry take feed until they satisfy their energy needs as primary, and usually all other nutrients are balanced against the level of energy input. In estimating the optimal diet energy, in addition to the recommendations, more information is needed to require, determine or adapt, in particular: to require all factors influencing the energy needs; to determine the precise production and environment conditions; to adapt (if necessary) energy recommendations to specific conditions and flocks. After completion of the growth and fulfilment of the body weight of adult layers, and after achieving the desired weight of eggs, which can be also influenced by the energy density of the diet, the energy of the mixture can be reduced as needed. The specifications of the need for macronutrients (proteins - amino acids, calcium, phosphorus, sodium, chlorides, linoleic acid and choline) for each hybrid are generally recommended in detail for each phase of nutrition and are shown in relation to feed consumption, so it is easy to adapt their level in the diet to the expected and achieved average feed consumption (energy) for a particular flock.

Monitoring of the flock in regard to meeting of the amino acid requirements and the fine-tuning of diets for adult layers is done based on the daily intake of amino acids and determined average daily weight of eggs. However, to which extent the individual needs of layers have been met depends on the achieved physical and productive uniformity of the flock, which decreases with the age of the flock. Therefore, in practice, the diets can be formulated with safe + 5% relative to the recommended amino acid concentrations (*Rutten, 2016*), if provided that the final production target (higher profit) with this change will be achieved. At the same time, in adult layers at the end of the laying period, the precision in the dosage of the diet proteins to some extent can control the optimum egg size, i.e. the quality of the egg shell, given that, according to *Bouvarel et al. (2011)*, 1 g of extra protein daily consumed by hen can increase the weight of the eggs by an average of 1.4 g.

For layers in the extended production cycle are very important the content and composition of fat and fibre in the diet for preservation of the health of the digestive tract (microbiota) and the liver, as well as precise consumption of calcium to preserve the quality of the egg shell and bones, and this must be paid special attention to.

Linoleic acid, essential fatty acids of well-known significance and influence, is recommended in the amount of at least 1% in the layer diet, which in practice is easily reached nutrition aspect. The problem with layers which has been in focus of research studies with limited success is the reduction of metabolic disorders and liver disease (hepatic steatosis – HS, fatty liver haemorrhagic syndrome - FLHS), to which modern layer hens are particularly susceptible. Hence,

many studies point to the importance of optimal, precise nutrition and energy throughout the entire production cycle of layers, as well as the replacement of a certain amount of carbohydrate with oils as a preferred source of energy for adult layers, in order to reduce the metabolic stress of the liver. In the recommendations of the hybrid manufacturers, the content of raw fats in the mixtures for layers, depending on their age, ranges between 2-5%, with the emphasis on the use of quality raw materials and antioxidant additives.

The importance of insoluble diet fibres (cellulose, lignin) in the extended laying period is increasingly emphasized, especially in two life periods of hybrids. In the period of rearing, it is recommended to include in the developmental mixture at least 5-6% due to better development of the digestive tract and increase of the ability to consume feed in young birds (*Lohmann Tiezucht, 2016*). The general recommendation is that 2.5-5% of insoluble fibres should be provided in the mixtures for hens during the laying period, based on numerous studies that showed their positive effect primarily on the digestive physiology and health of the microbiota of intestines (*Hendrix Genetics, 2018*). For older layers, moderate energy dilution of the diet is recommended by increasing the percentage of crude (insoluble) fibres to 6-7% in the mixture, which indirectly can positively affect the liver health, absence of incidences of cannibalism and a better consistency of faeces.

Prevention of osteoporosis in older layers and especially preservation of shell quality by nutrition should not be ignored when the laying cycle is extended. For the expected 500 eggs in the extended continuous laying capacity, the hen must be able to extract and incorporate in the shell over 1 kg of calcium. Hence, the significance and all aspects of nutrition and metabolism of calcium in laying hens have been intensively researched for decades, described and optimized in practice by a series of applied solutions and techniques (e.g. *Bouvarel et al., 2011; Lukić et al., 2011; Thiele et al., 2015*), but still excites researchers' interest. In general, adequate nutrition of layers with calcium implies the right solution for three essential diet aspects: the adequate source of calcium in the appropriate form and ratio (ratio of powder : 1.5-4mm granules); an adequate level depending on the age and feed consumption of the layers; the proper feeding technique to make calcium available at the right time and the right place in the body of the layer during the laying period. Attention should also be directed towards the adequate source and concentration of other minerals and vitamins essential for the formation of egg shell (*Nys et al., 2018*).

The recommended concentrations of micronutrients - vitamins and microelements, which are usually incorporated in diet by premix, are generally similar for adult layers in most hybrid manufacturers. However, if eggs with an increased content of certain microminerals or vitamins are production goal,

additional and precise fortification of the diet with certain micronutrients is necessary (Bouvarel *et al.*, 2011; Wang *et al.*, 2017; Nys *et al.*, 2018). Also, certain modification of used amount or form of some micronutrients and vitamins, as well as some additives inclusion can also have beneficial impact on liver health and the prevention of metabolic diseases. The inclusion of inositol in feed, vitamin D in the form 25 (OH) D<sub>3</sub> or certain herbal extracts, has shown potential to reduce oxidative stress of the liver and the occurrence of HS and FLHS in layers, and in practice, a certain increase in choline concentration, vitamin K<sub>3</sub>, B<sub>12</sub>, folic acid and vitamin E is implemented by incorporating in the feeds of one of the products for the preservation of liver health based on the combination of these vitamins (Pottgüter, 2016; Wang *et al.*, 2017).

In general, scientific research has so far identified nearly 40 nutrients that need to be provided to laying hen through diet, in optimal amounts, quality and interrelation. Usually, 4-5 (if necessary more) of the pronutrients and additives are added to the layer mixtures, in order to improve performance and to solve potential or current problems. That is why the proper diet of modern layer hybrids is considered one of the most demanding tasks in production, especially since there is no more standardized way of poultry farming, but a whole range of different ways and conditions for the production of table eggs, including the fact that the continuous laying cycle of the flocks is getting longer. Moreover, the question of full relevance of previous research, knowledge and recommendations, as well as their applicability can be raised without additional research and adaptation of the technology of feeding to new genetics, new conditions and new challenges – extended production cycle.

## **Dynamics and method of daily feeding**

Layers can be feed *ad libitum* with well balanced diet because they are able to adjust the intake of feed to their needs and the density of nutrients in the mixture, and usually there is no overfeed. However, this mechanism is not completely precise. In particular, there is a danger of lower feed intake or imbalance of certain nutrients, such as amino acids or calcium, especially if there is an imbalance of energy and other nutrients in the diet, or in the diet with heterogeneous flour mixtures from which layers prefer to select larger particles.

Given the extremely high intake and excretion of nutrients in high-productive layer hybrids during each production day, it is important to properly satisfy the needs for particular nutrients even during the different parts of the daily cycle. The formation of eggs in the oviduct after ovulation, i.e. single ovulation cycle (from ovulation to oviposition) on average in modern layers lasts about 24 hours (Nys and Guyot, 2011). The ovulation is preceded by long multi-phase

development of the egg cell and the formation of the yolk in the ovary, with about 98% of the contents of egg yolks being deposited linearly during the final 7-11 days before ovulation, primarily lipids and proteins synthesized in the liver.

Most layers lay eggs (oviposition) in the morning, most often during the first hour after the start of the light part of the day cycle. During the formation of eggs, the first hours after ovulation albumen and egg membranes are formed, most often in the morning hours, followed by over 19 hours of formation and mineralization of the egg shell, mostly in the afternoon and at night (the most intense 10-22 hours after ovulation). It is therefore considered that in the case of layers, in the morning (oviposition, ovulation and formation of albumin), energy and amino acid requirements may be increased. Also, it has been proven that the need and appetite for calcium is rapidly increasing in the afternoon and at night (formation of the egg shell).

The right way of daily feeding should ensure that the necessary nutrients are available at the right time during the day for absorption in the intestines of highly productive layers. Therefore, hybrid manufacturers recommend feeding at least twice a day. A smaller portion (40%) of the total daily diet is given during morning feeding, and 60% in the afternoon, six to seven hours prior to turning off the light, which is a recommendation based on observation of the usual behaviour and appetite of layers during the day. It is also necessary that feeding be organized so that layers consume all the feed, so that the feeders are empty in the short time between these two feedings, to ensure that the smallest feed particles are consumed.

New method of feeding are studied, so-called “sequential” layer nutrition, in order to more precisely satisfy the needs during the daily production cycle. The feeding method of young layers was studied, where they were fed in the morning with an energy-fortified mixture, and in the afternoon with a mixture rich in proteins, calcium and micronutrients, which resulted in better utilization of feed and quality of egg shell with unchanged productivity, but accompanied by weight loss due to less consumption (*Batonon et al., 2014*). *Crots (2016)* reports the positive effects of specially designed sequential feeding in practical conditions for a successful extension of the production cycle, while *Molnar et al. (2018)* summarize all previous research on this subject in excellent review paper. In practice, further research is needed to apply this nutrition technique in practice, in particular its effects in the extended exploitation of coming hybrid layers.

**The dynamics of changing of the mixture formulation during the production cycle – is improvement possible?**

Some hybrid manufacturers suggest that it is necessary for the nutrition program to be as simple as possible with a limited number of feed changes in order to avoid mistakes in the layer nutrition chain (*Hendrix Genetics, 2018*), while others recommend that every 10 weeks during the production period the formulation of diet is adjusted to the current level of production and given recommendations for layer requirements (*Lohmann Tiezucht, 2016*). However, both warn that major changes in the raw material composition, quality and form of diets should be avoided, since layers are sensitive to rough changes in the basic characteristics of the diet.

Having constant, high-quality production monitoring is a prerequisite for success, as well as so-called “fine tuning”. It is not enough to just collect data, but the data collected must be real: relevant, representative, reliable and continuously monitored. Also, data without sound analysis and adequate and timely action mean nothing.

In order to improve the nutrition of layers, we can go further than that, which requires close cooperation between egg producers and feed producers. By constantly monitoring the complete production process and the quality of the product (egg producer), creating a quality database and expert analysis (a nutritionist or a feed manufacturer), primarily of the relationship between feed and production (the quality of feed ↔ the consumption ↔ intake of nutrients ↔ the response of layers ↔ the quality of eggs), errors can be avoided, and the nutrition program constantly optimized, if necessary with each subsequent delivery of feed, which is a new level of animal feeding - a proactive precision nutrition. It requires knowledge and experience of functioning of both systems, the (industrial) processes outside the hen, as well as in the biological systems (organism and organs) of the bird. New tools, application of sensors, information technology and modelling in the control and analysis of production, products and animal feed greatly facilitate work and widen the opportunities.

We need to find a measure, in larger interventions and frequent feed changes (to which the layers need to adapt), as well as in the method of applying precision nutrition, which should not be too complicated in order to remain practical and acceptable to a large number of feed manufacturers and table egg producers. On the other hand, the more accurate and precise nutrition of the layer, the greater are the chances that the genetic potential and resources are optimally used, i.e. to have less nutrients in the manure and more in the eggs.

The already mentioned sequential nutrition is being investigated and increasingly discussed, as well as the free choice method, as an easy way for each layer in a flock to be independently and in a natural way balance its daily ration (*Molnar et al., 2018*). These nutrition techniques could be widely accepted in the future, but with further necessary intensive research and development.

## Conclusion

Adequate and high-quality nutrition of modern layers keeping on 100 week marathon of production of table eggs has a decisive impact on that how successful and for how long the high laying capacity, good quality of the eggs, and the animal health will be maintained. For maximum production results, so-called "one-size-fits-all" feed solutions are not sufficient. They are possible by the use of precision nutrition and specially formulated rations for specific conditions and flocks. The precondition for this is the multifactorial approach and close cooperation between breeders, nutritionists and egg producers.

## Gajenje i ishrana kokoši nosilja 100 nedelja za maksimalnu nosivost

*Miloš Lukić, Zdenka Škrbić, Veselin Petričević, Vesna Krnjaja, Zorica Bijelić, Nikola Delić*

### Rezime

Savremene hibridne nosilje uskoro će biti moguće držati bez mitarenja do 100 nedelja, umesto 70 ili 80, sa produkcijom blizu 500 jaja po nosilji. U radu se raspravlja o najnovijim saznanjima o gajenju i ishrani ovih visoko sofisticiranih, izuzetno produktivnih i vrlo zahtevnih ptica tokom produžene neprekidne nosivosti. Diskutuje se o strategiji ishrane, potrebama i preporukama, dinamici ishrane tokom dana i tokom proizvodnog ciklusa, novim tehnologijama i tehnikama ishrane. Rad ima za cilj da doprinese rešavanju izazova koji se očekuju širom primenom duže neprekidne eksploatacije nosilja genetički sposobnih za to. Maksimalni proizvodni rezultati dostižni su preciznom ishranom namenski formulisanim obrocima, kao i što dužim očuvanjem zdravlja nosilja i kvaliteta ljuske jaja pravilnom ishranom. Preduslov za to je bliska saradnja odgajivača životinja, nutricioniste i proizvođača hrane.

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