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**ENHANCEMENT OF EFFICIENCY OF IRRADIATION FACILITY FOR  
DOMESTIC BIRD HUSBANDRY**

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**Abstract:**

This article deals with the issues of influence of the spectral distribution of the emission sources on the productive performance of poultry (chicken), the efficacy of irradiation lighting engineering installation. The model of function of relative spectral sensitivity of the organ of vision of biological object as a basis for selecting the spectral quality of the radiation sources in order to increase their effectiveness is offered. The article concerns the development and testing of irradiation lighting engineering facility, including radiation sources, estimated by use factor of the radiation by the organ of vision of poultry (chicken) according to the proposed function of relative spectral sensitivity of the visual organ of the bird (chicken).

**Keywords:** spectral sensitivity, modeling, factor of radiation use, efficiency, radiation sources, visual organ.

**1. Introduction**

Implementation of the State program of agricultural development for 2013-2020 aims to promote the growth of production of major agricultural products, increase of profitability. It has been established in this day that the effectiveness of the artificial lighting in the agricultural sectors is largely dependent on the used optical radiation sources being adapted to the spectral sensitivity of the biological object. For biological objects, including birds, the functions of spectral sensitivity of the visual organ are different [1].

Solving optimization problem of technological lighting and radiation is made up of, as much as possible, complete satisfaction of physiological requirements of the birds to light, and of the research and development of engineering facilities to create an improved light color environment. However, in the practice of lighting technology application, until recently, nobody have not taken into account the peculiarities of perception of visible light by the organ of vision of poultry (chicken). The researches of Russian and foreign scientists cover the issues of development of the ideas of

the function of relative spectral sensitivity of the organ of vision (FRSSOV) of poultry, as well as the selection and the modernization in accordance with its radiation sources.

The development of new ideas of the function of relative spectral erythema efficiency opens up the possibilities of improving the irradiation equipment for lighting technology and exposure in aviculture.

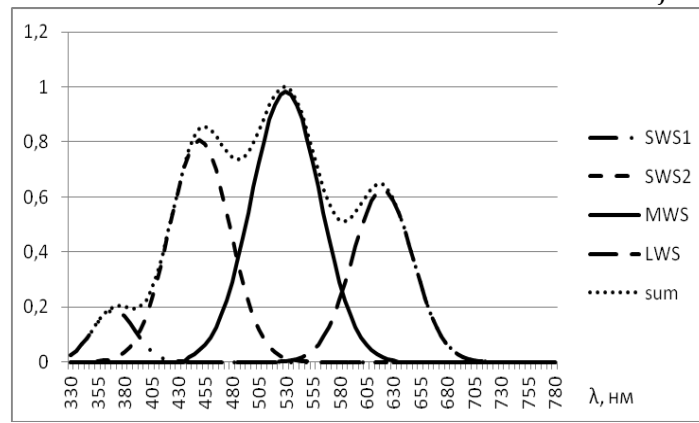
## 2. Frssov of Poultry – The Basis of Selection of Spectral Quality of Light Source for Poultry Breeding

The development of ideas about the FRSSOV of the biological object is the basis for the development of efficient light sources, lighting devices and facilities based on them. The basic developments in this area were carried out for the function of luminous efficacy of the human organ of sight, in this connection with which we have made an analogy for the birds. The research of FRSSOV of the birds confirm that the function of relative spectral sensitivity of the visual organ of poultry has a local maxima in the ultraviolet, blue, green and red spectral regions [2-5]. However, these authors differ in the levels of maxima, the location of these peaks wavelength, which makes it difficult to use a function of relative spectral sensitivity of the visual organ of the birds in practice when selecting the spectral quality of the radiation sources in the lighting installations.

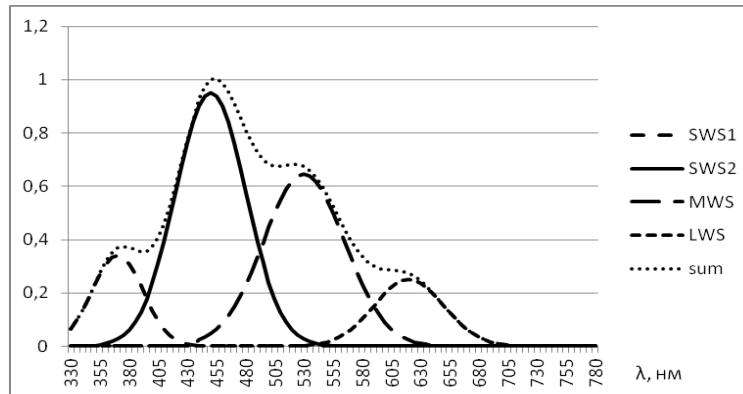
Based on theoretical research and scientific priori data, the description of the FRSSOV of birds to assess and improve the spectral quality of the radiation sources used in poultry factories is offered. The suggested description of the FRSSOV of birds has been realized in a program that allows to get a table and graphical representation of the FRSSOV of poultry [6]. As the basis functions for modeling the FRSSOV of poultry, four bell-shaped curves (components) with sensitivity maxima in the red (R or LWS), green (G or MWS), blue (B or SWS2), ultraviolet (UV or SWS1) areas were taken [7]. As a result, two variants of building the model of the FRSSOV of birds having good convergence with the research data given in the materials have been obtained: the first variant - N.B. Prescott & C.M. Wathes (Figure 1); the second variant - free Russian encyclopedia “Tradition” and Bowmaker (Figure 2). Inaccuracy relative to the local maxima of FRSSOV of the birds of the modeled curve according N.B. Prescott & C.M. Wathes is reduced to zero. As an approximating expression for the components of the curves the following function is used:

$$K(E, \Delta\lambda_i) = \sum_{i=1}^n \frac{k_i A_i(E)}{\sigma_i \sqrt{2\pi}} \exp\left(-\frac{(\lambda - \lambda_{maxi})^2}{2\sigma_i^2}\right), \quad (1)$$

Where  $A_i$  – dependence of the levels of maxima of the curve of spectral efficiency on irradiance in the corresponding spectral range at a constant factor  $\sigma_i$ ;  $\lambda_{maxi}$  – wavelength at which the maxima of spectral efficiency in the region fall (nm),  $k$  – scale factor [1].



**Figure 1 - The result of modeling the FRSSOV of the birds (variant 1)**



**Figure 2 - The result of modeling the FRSSOV of the birds (variant 2)**

According to the FRSSOV of the birds, the use factors of radiation source of optical radiation were calculated by formula 2,

$$K_{спекри} = \frac{\int_{\lambda_{1i}}^{\lambda_{2i}} \varphi_e(\lambda) s(\lambda) d\lambda}{\int_{\lambda_{10}}^{\lambda_{20}} \varphi_e(\lambda) d\lambda} \quad (2)$$

где  $s(\lambda)$ - relative spectral sensitivity of the visual organ of the biological object,  $i$  – corresponding spectral ranges,  $\varphi_e$  - spectral distribution of the radiation power [8].

The analysis of the result of the calculations of the radiation use factors for the FRSSOV of poultry corresponding to the data of free Russian Encyclopedia “Tradition” and Bowmaker has shown that the traditional light sources (lamps such as DRI, DRL, LB, LBTS, LD) have the radiation use factor for the visual organ of birds of about 50% but their spectral coefficient in the UVB but DRI lamp type is almost equal to zero; in a combination of blue-green light-emitting diodes and ultraviolet light source the use factor is 65% or higher, the maxima of the combined spectrum of the radiation sources correspond to the FRSSOV of the birds. The analysis of the results of calculation of emission use factors for the FRSSOV of the birds corresponding to the data suggested by N.B. Prescott & C.M. Wathes (Fig. 3) has shown the same dependence as that on the FRSSOV of poultry corresponding to the Russian free encyclopedia

“Tradition” and Bowmaker (Fig. 4).

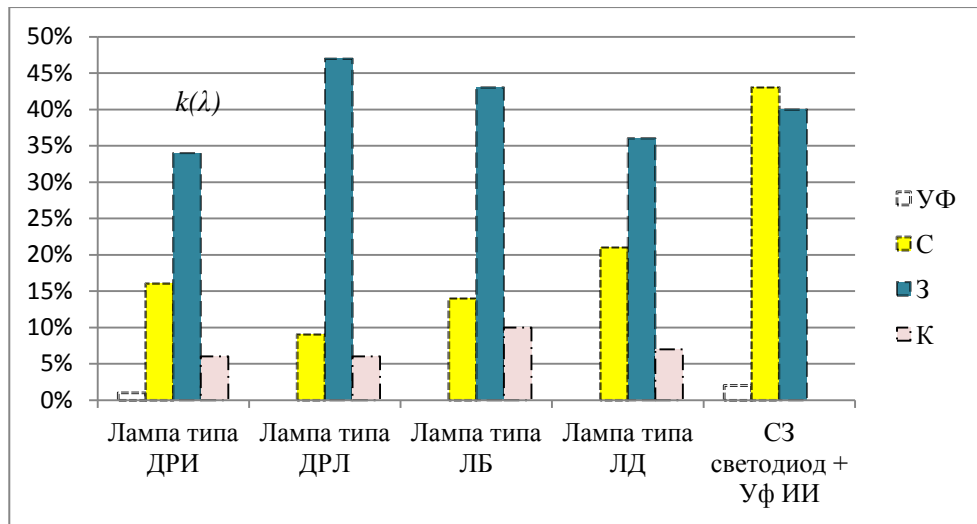


Figure 3 – A graphic representation of the radiation use factor by regions (variant 1).

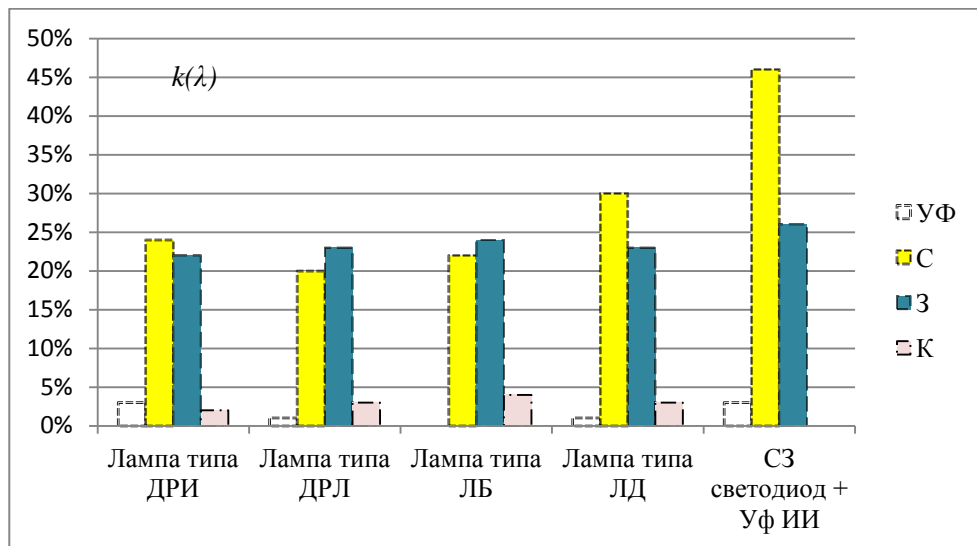


Figure 4 - A graphic representation of the radiation use factor by regions (variant 2).

The calculations have also revealed that the values of the radiation source factor may have different values right up to 100%. This points to the need for continued research on improvement of the spectral quality of the radiation sources and their combinations in order to identify the most efficient light sources for the corresponding application sector [1].

### 3. The Development of Lighting Engineering Facility with Spectral Distribution of Radiation Sources Adapted To Erythema and the Frssov of Poultry

Based on the simulated emission spectrum according to the proposed descriptions of the FRSSOV of birds with the highest emissivity factor, Irradiation lighting facility (ILF) has been developed, which includes a module of the LED blue-green clusters on the basis of the p-n-junction in the InGaN, combined in one construction with erythemal lamps LE-15 and bactericidal lamps DB-15. Irradiation facility is multifunctional. Radiation of erythemal lamps LEB-15 in A B of UV spectrum with emission peak wavelength of 315 nm and germicidal lamps DBM-15 in the field of UV-C

spectrum with a maximum radiation wavelength of 254 nm has an erythematous antirahitnym action. Decontamination of the microclimate of the poultry-house is provided by the unit: the irradiator-recirculator with bactericidal lamps DBM-15 provides for disinfection and decontamination of air flows in the zone of poultry keeping. The radiation in the optical range, perceived by the organ of vision of the bird, is provided by a removable module with light-emitting diode clusters and erythema lamps [9].

Measurements of the parameters of the prototype of ILF were performed, on the basis of which the radiant intensity curves were constructed with intervals of  $10^\circ$ , which were used to calculate the parameters of the light color medium. To estimate the spectral quality of the combined facility there were measured the spectral characteristics of radiation sources. The spectral distribution of LEDs and fluorescent lamps, their energy flows were obtained by means of spectroradiometer OL770 in CCU of light engineering department of FSBEU of Moscow State University named after N. P. Ogarev in accordance with the recommendations of the International Commission on Illumination (ICI). The ambient temperature was constant throughout the experiment. Limits of permissible absolute error of measuring the chromaticity coordinates:  $\Delta x=0,0002$ ,  $\Delta y=0,0004$ . For a combined facility, the emission factors for use the FRSSOV of birds according to encyclopedia "Tradition" and Bowmaker and according to N.B. Prescott & C.M. Wathes respectively accounted for 62% and 80, 3%. [1, 10].

A pilot sample of the combined lighting irradiation facility is shown in Figure 5.



**Figure 5 - Combined Irradiation Lighting Facility [11]**

The studies on the effect of the spectral distribution developed by ILF on productive and physiological indicators of hens in the section young breeder "ROSS – 308" were conducted. Together with this facility an installation with traditional lamps of LB-40 type was used. They created an average illumination of 76 meter-candela. In the section of young poultry breeding the territory of width of 2.5 m and length of 4,7m for ILF location was allotted. Of one-day-old rearing chickens and cockerels from industrial flock cross "Ross 308" in each test by the method of analogues there were formed two groups - control (base) and experienced (30 heads of males and 50 heads of females). The bird

housing conditions of control and experimental groups were similar and provided in accordance with the guidance on the parent flock of “Ross 308”. In the control (basic) variant for general lighting there were used fluorescent lamps of LB 40 type, in the pilot variant in addition to the fluorescent lighting there was used the combined facility with ultraviolet lamps and blue-green clusters. Doses of radiation and lighting were determined in accordance with the recommendations on the application of ultraviolet radiation in animal husbandry and poultry farming. Irradiation mode was intermittent. [12] In on-the-farm research, based on the influence of the spectral quality of the radiation sources on the young birds, the following indicators were considered and determined: input parameters - dose and exposure time, weekend - flock uniformity, livability of livestock, egg producing ability per average hen, egg yield, live weight of birds. A comparative analysis of the farm test has concluded that the developed method of lighting and irradiation allows to: increase productivity (up to 10%), uniformity of farm rearing flock (up to 9%), viability of the birds (4%) [1].

To identify the resource of cost savings by using the developed irradiation systems for 10 sections with young birds, engineering and economic comparison of the costs for a period of 10 years was carried out. The total costs by using combined irradiation facilities proved to be by 6% lower than the total reduced costs by using facilities with fluorescent lamps (base variant) [1].

#### **4. Summary**

Based on the above, it can be concluded that the developed combined irradiation facility enables to improve the parameters of the light color medium of poultry farms, to implement lighting functions, erythemal and antibacterial irradiation and to increase the energy efficiency of ILF.

#### **5. Conclusion**

Thus, the developed mathematical description of the relative function of spectral sensitivity of the organ of vision of poultry allows its quantification and use in calculating radiation use factors, which objectively leads to the choice of optical radiation sources used in the poultry industry. Based on the above, one can conclude about the prospects of application of the developed combined irradiation lighting facility with an offer of specific technical solution, adapted to the FRSSOV of birds for domestic bird husbandry.

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