UDC: 638:628.8 DOI: https://doi.org/10.53040/ppap2026.48

# IDENTIFICATION OF TECHNOLOGICAL SOLUTIONS TO ENSURE ABIOTIC FACTORS: COOLING, AIR HUMIDIFICATION, LIGHTING AND VENTILATION SYSTEMS USING AN ENGINEERING-TECHNOLOGICAL APPROACH

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**Objective:** To identify effective technological solutions for controlling abiotic environmental factors – temperature, humidity, lighting and ventilation – in industrial insect farming systems (entomocultures), with a focus on energy efficiency and economic viability.

**Materials and methods:** The study is based on an analysis of comprehensive, integrated, automated microclimate control systems comprising a central controller, environmental sensors, actuators and software, which provide real-time monitoring, automatic correction of deviations and the capability for remote control. An eight-stage engineering and technological algorithm for equipment selection was applied: 1) determination of microclimate requirements; 2) assessment of current conditions and constraints; 3) selection of technologies for each parameter; 4) energy audit (capacity, operating time, consumption, cost); 5) assessment of economic efficiency (initial costs, operating costs, maintenance); 6) comparison of alternatives; 7) integration and automation; 8) monitoring and optimisation.

A comparative analysis was carried out of renewable energy sources (solar, wind, bioenergy, hydropower, heat pumps and hydrogen) and the spectral characteristics of LED lighting with regard to their impact on the circadian rhythms, reproduction, behavioural activity and stress resistance of insects.

**Results:** The combination of heat pumps, LED lighting, heat-recovery ventilation and contact surface humidification has been identified as the most energy-

efficient configuration for industrial insect farming. Automated microclimate control reduces operating costs by 20-30 per cent and increases bioproductivity by 30-50 per cent. Stabilising microclimate parameters ensures a 20-40% increase in larval viability, a 20-30 % acceleration in development, a 15-25% increase in reproductive capacity when the photoperiod is maintained, and a 30-50% reduction in mortality. LED lighting consumes 5-10 times less energy than incandescent bulbs and offers an efficiency of 100-160 lm/W, compared with 70-90 lm/W for HPS lamps and 60-80 lm/W for fluorescent lamps. Among renewable energy sources, solar, wind and bioenergy best meet the criteria of safety, self-sufficiency and environmental friendliness for small and medium-sized insect farming operations.

**Conclusions:** The proposed engineering and technological method, which combines a structured algorithm for equipment selection, a comprehensive integrated automated control system and an energy-efficient equipment package (heat pumps + LED lighting + heat-recovery ventilation + contact humidification), enables the rational selection of process equipment, reduces operating costs, improves the stability of microclimate parameters and achieves energy savings without compromising the quality of the entomocultivation biological process.

**Keywords:** insect farming; microclimate; energy efficiency; automation; LED lighting.