no. 1 (2026), pp. 116-124
ISSN 1857-0003 E-ISSN 2587-3202

https://doi.org/10.55505/sa.2026.1.12
UDC: 638.142.384.3

STUDY ON THE USE OF DIFFERENT TYPES OF ARTIFICIAL HONEYCOMBS IN BEE EXPLOITATION

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Abstract. The purpose of the research is to study the use and evaluation of the growth of different types of artificial honeycombs. Following the assessment of the intensity of acceptance and cell formation by bees of different types of artificial honeycombs: coloured, simple, ecological and traditional ones, it was revealed that newly built honeycombs have a light-yellow colour and worker bees give priority to the construction of cells from wax capping and to the simple ones compared to the traditional ones. Worker bees gave priority to the coloured artificial honeycomb, and it was accepted for cell growth, keeping the red colour compared to the simple and traditional honeycombs. Artificial combs made of wax capping (ecological) are the most accepted for cell formation by bees and honeycomb construction.

Keywords: *Beeswax; Comb honey; Honeycombs; Artificial comb foundations.*

Rezumat. Scopul cercetării constă în studierea utilizării și evaluării dezvoltării diferitelor tipuri de faguri artificiali. În urma evaluării intensității acceptării și formării celulelor de către albine pe diferite tipuri de faguri artificiali: colorați, simpli, ecologici și tradiționali, s-a constatat că fagurii nou construiți au o culoare galben-deschis, iar albinele lucrătoare manifestă o preferință pentru construirea celulelor din ceară de căpăceală și pentru fagurii simpli, comparativ cu cei tradiționali. Albinele lucrătoare au acceptat cu prioritate fagurii artificiali colorați, menținând culoarea roșie a acestora în procesul de extindere a celulelor, în comparație cu fagurii simpli și tradiționali. Fagurii artificiali confecționați din ceară de căpăceală (ecologici) prezintă cea mai ridicată rată de acceptare pentru formarea celulelor și construirea fagurilor de către albine.

Cuvinte-cheie: *Ceară de albine; Miere în figure; Faguri; Foi de ceară artificială.*

INTRODUCTION

Artificial honeycombs are essential for bee colonies, as they provide space for storing honey and pollen reserves and for the development of brood, representing the new generations of bees. According to the applicable standards, foundation sheets must be produced exclusively from first-class beeswax and must not contain any foreign substances. In recent years, increasing concern has been raised regarding the poor quality of artificial honeycombs available on the market, many of which may contain harmful adulterants or other added substances (Trzybiński, 2020).

An artificial honeycomb is a wax sheet that serves as the foundation for honeycomb construction, providing bees with a base on which to build their combs. Artificial wax foundations are manufactured in different sizes according to the dimensions of the hive frames in which they are installed.

The main purpose of using artificial honeycombs is to accelerate cell construction, thereby promoting faster colony development and improving bee productivity. However, some wax producers do not comply with quality standards and, in order to reduce production costs and increase profits, adulterate beeswax with cheaper substances such as paraffin, stearin, ceresin, and other additives, which negatively affect the properties and quality of the wax (Osiptan et al., 2010).

The quality assessment of artificial honeycombs can be divided into organoleptic and laboratory evaluations. Organoleptic evaluation is based on sensory characteristics, including colour, odour and appearance, whereas laboratory evaluation requires specialized equipment to objectively determine the chemical, physicochemical and physical properties of the wax. Artificial honeycombs should be manufactured exclusively from high-quality natural beeswax, as the presence of foreign substances such as paraffin, pesticides or other chemical compounds is not accepted by bees. In particular, paraffin is considered unsuitable because it has a lower melting point than beeswax, and its addition reduces the mechanical strength of artificial combs (Mateev, 2025).

The artificial comb in the hive has three main functions: it serves as a comb for brood development, as a temporary storage place for pollen, where it is converted into bee bread, and as a storage area for the colony's honey reserves. Artificial foundation sheets enable bees to build combs with less effort, while the hexagonal pattern of the worker-cell bases discourages the construction of drone and queen cells (Eremia, 2009).

An invention has been developed that relates to the formation of an artificial foundation sheet used as a base for comb construction. The sheet has a planar shape and comprises a three-dimensional network structure defined on both sides. This invention generally refers to improvements in honeycomb foundation sheets intended for use in beehives and also has applications in the production of lightweight structural panels (Clerkin, 2025).

It has been reported that bees begin constructing artificial combs within the first week after the foundation sheets are introduced into the hive (Eremia et al., 2016). The growth and development of honeybees are influenced by several factors, including the size of brood comb cells. Research findings confirm that cell size affects honeybee development, with drones reared in larger cells reaching larger body dimensions (Yang, 2025). However, combs made from beeswax have relatively low mechanical strength, which makes them vulnerable to damage during the extraction process. Moreover, beeswax honeycombs are easily damaged under field conditions and are frequently affected by wax moth infestation.

It was found that some artificial wax honeycombs do not comply with the requirements of the GOST 21180-2012 standard "Wax honeycombs. Technical specifications" and contain various additives in different proportions. Therefore, an organoleptic method for assessing the quality of wax honeycombs was developed, which allows the identification of additives, their quality assessment and determination of the suitability of such combs for use in apiaries (Zykina et al., 2025). The reuse of honeycombs may contribute to the transfer of pigments into honey, which can subsequently influence its final characteristics.

Honeycombs consist of cells with three orientations – vertical, intermediate (oblique) and horizontal – and the proportion of cells in these three orientations may vary.

The formation of artificial honeycomb cells with a rounded hexagonal shape has been studied, showing that bees knead, heat and thin the wax precisely in the areas required for comb construction. During this process, the cell walls are continuously stretched, increasing the contact surface between them and becoming straighter, which

results in the formation of a hexagonal network of cells with sharp angles. The hexagonal shape of comb cells allows bees to use available space most efficiently, producing a lightweight but strong structure with minimal wax consumption and maximum honey storage capacity (Karihalo et al., 2025).

The addition of foreign substances, such as paraffin, beef tallow and stearic acid, which are frequently used for beeswax adulteration, negatively affects the physicochemical properties of wax, reducing its quality and, consequently, the quality of artificial combs produced from adulterated beeswax (Bogdanov, 2004; Waś et al., 2015).

When small quantities of foreign substances are introduced into beeswax, classical qualitative physicochemical analytical methods do not always allow their accurate detection (Svečnjak et al., 2015). Beeswax used in beekeeping for the production of artificial combs and coming into contact with honey intended for human consumption is not subject to mandatory quality control before being placed on the market (Svečnjak et al., 2019).

Monitoring the acceptance of artificial combs introduced during the research demonstrated that, in the absence of sufficient natural nectar collection, intensive wax production does not occur. As a result, the quality of the constructed combs is poor, with a high proportion of drone cells and irregularly arranged cells. The influence of unfavourable weather conditions on the rate of artificial comb construction was also observed (Sava et al., 2025).

Research conducted in Spain revealed beeswax adulteration with different proportions of added waxes. The presence of foreign waxes was confirmed in 33 out of 90 analysed samples, with adulteration levels ranging from 5% to 30% (Bonvehi et al., 2012).

In Belgium, a frequency of adulteration between 9.2% and 33.3% was revealed, respectively, in beeswax samples from beekeepers (9 samples out of 98: 2 with paraffin and 7 with stearin/stearic acid) and in commercial beeswax samples (3 samples out of 9: all adulterated with stearin/stearic acid). In the analysed samples, different percentages of paraffin (between 12% and 78.8%) and stearin/stearic acid (1.2 to 20.8%) were detected. There emerged the problem to protect the health of both honeybees and consumers (Noëmie et al., 2021). It has been shown that the level of adulteration with paraffin is much more pronounced (74%) than with stearic acid (26%) (Chatzipanagis et al., 2024).

It has been assessed that the external factors (climacteric, lack of nectar collection) influence the process of cell formation in the comb, so that unbalanced, non-hexagonal cells are built. Bees from colonies with new combs were more active in the formation of pollen and honey reserves, as well as in the development of the strength of the bee colony, while the body size of the bees and productivity decreased in colonies with old combs (Taha et al., 2021). However, some research has shown that bees do not always reject artificial combs with adulterated wax, regardless of the level of adulteration used, if they have abundant nectar sources (Jiménez et al., 2007). EFSA lists some proposals for assessing the risks of the impact of adulterated beeswax for both humans and bees (EFSA, 2020).

The purpose of the work is to study the use and evaluation of the growth of different types of artificial honeycombs in the development and productivity of bee colonies.

MATERIALS AND METHODS

To achieve the proposed objective, investigations were carried out using different types of artificial honeycombs in the management of honeybee colonies at the apiary of the Peasant Household “Tudorean Procopii”.

The study material consisted of artificial honeycombs of different types and origins used for the exploitation of bee colonies.

The artificial honeycombs evaluated in the study included: foundation sheets produced from capping wax, foundation sheets produced from wax recovered from discarded combs, foundation sheets produced from coloured wax, and traditional artificial honeycombs (Figures 1–4).

Figure 1. *Artificial honeycombs from capping (ecological)*

Figure 2. *Wax from discarded frames*

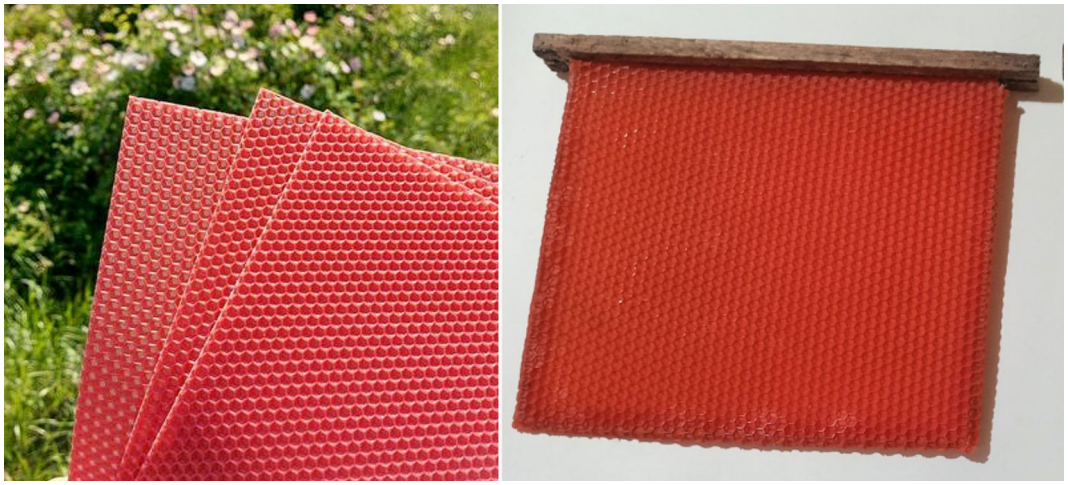


Figure 3. *Artificial honeycombs made of coloured wax*

Figure 4. *Traditional artificial honeycombs*

According to the requirements of GOST 21180-2012 and GOST 21180-2013, artificial wax foundation sheets must be produced exclusively from first-class beeswax and must not contain any foreign substances. The presence of adulterants can only be confirmed through complete laboratory analysis. In practice, the naturalness and quality of wax are also reflected by the good health of bee colonies and the presence of abundant food reserves stored in the comb cells.

Beekeepers can produce artificial honeycombs from beeswax obtained in their own apiaries, either by recycling discarded combs or by using wax cappings collected during honey extraction. This practice ensures that the foundation sheets are made from natural beeswax of known origin.

To accomplish the objectives of this study, different types of honeycombs were used that were introduced into the hive at the same time, with the same maintenance of the bee families.

The following types of artificial honeycombs were used in the study:

- Wax foundations from cappings – obtained from the wax caps removed from sealed honey cells using a beekeeping knife. Wax from cappings is considered to be of high quality and almost pure.
- Wax foundations from discarded combs – produced by melting old honeycombs, characterized by yellow, light or dark brown, light grey or dark yellow-orange colour with reddish shades and a non-uniform colour at the fracture surface.
- Coloured wax foundations – produced from capping wax coloured with natural food dyes and formed by molding.
- Traditional wax foundations – produced from beeswax without information regarding the method of production or wax composition.

According to GOST 21180-2013, the assessment of artificial wax honeycombs was carried out organoleptically by determining the colour, odour, the presence of mechanical damage, the presence of moisture on the surface of the sheet, the shape of the wax foundation sheet, and the shape of the cell bases.

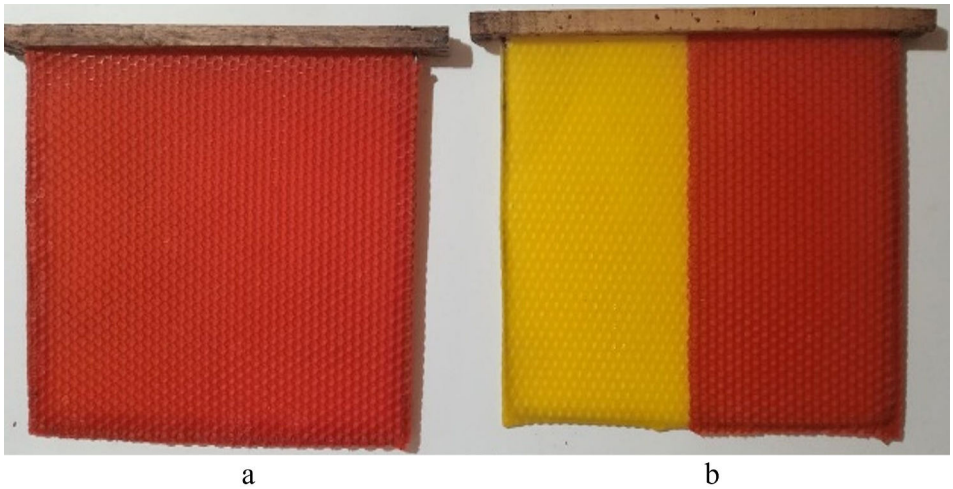
RESULTS AND DISCUSSIONS

According to GOST 21180-2012 “Artificial honeycombs. Technical specifications”, artificial honeycombs should be produced from a wax composition prepared on the basis of beeswax complying with GOST 21179-2000, with the addition of up to 10% industrial wax in accordance with DSTU 4667:2006 “Industrial beeswax. Technical specifications”.

The naturalness of beeswax cannot be determined solely by its colour, as this characteristic is useful only in cases of pronounced adulteration. In general, colour is used mainly for determining the wax group. The odour of wax can indicate the presence of additives such as rosin, ceresin, paraffin, crude lard, stearin, lanolin, carnauba wax, or Japanese wax. Taste may also reveal the presence of paraffin or ceresin, which are not characteristic of natural beeswax. Additions of rosin, stearin, and Japanese wax at concentrations of approximately 10% increase the brittleness of artificial combs, whereas the addition of crude lard decreases their brittleness (Mateev, 2025).

The recognition of natural artificial honeycombs and their differentiation from adulterated ones is based on several organoleptic indicators. Colour – natural honeycombs usually have a golden or amber colour that varies depending on the botanical origin of the nectar, whereas adulterated combs may appear excessively glossy or have an unnatural colour. Structure – authentic artificial honeycombs consist of regular hexagonal cells made of beeswax and have a slightly waxy and flexible texture, while adulterated combs may be stiffer or excessively smooth. Odour – natural honeycombs possess a characteristic sweet and floral aroma derived from honey and natural beeswax, whereas a chemical odour or an excessively sweet smell without floral notes may indicate adulteration. Taste – genuine honeycomb has a complex flavour profile influenced by the floral source of nectar, while adulterated combs may have little flavour or an unpleasant chemical aftertaste. The consistency of artificial honeycomb depends on the temperature of the environment, from soft to firm as the temperature increases. The structure of the cells of artificial honeycomb upon inspection – natural honeycomb has a well-defined hexagonal structure, while fake honeycomb versions may have irregular shapes or look more like molded plastic (Eremia et al., 2016; Красочко & Еремия, 2022a; Красочко & Еремия, 2022 b).

Figure 5 shows the frame with the artificial honeycomb used in experiments (1) fully coloured and (2) – 50% coloured and 50% traditional.



a b

Figure 5. *Frames with artificial honeycombs:*
a – fully coloured artificial honeycomb
b – traditional and coloured artificial honeycomb

Figure 6 shows frames filled with simple, coloured artificial honeycomb from capping and, in the process of growth, built by worker bees during a week. The worker bees built cells of the coloured beehive where they kept the red colour. It turns out that they used coloured wax to form the walls from the thickness of the artificial honeycomb used.

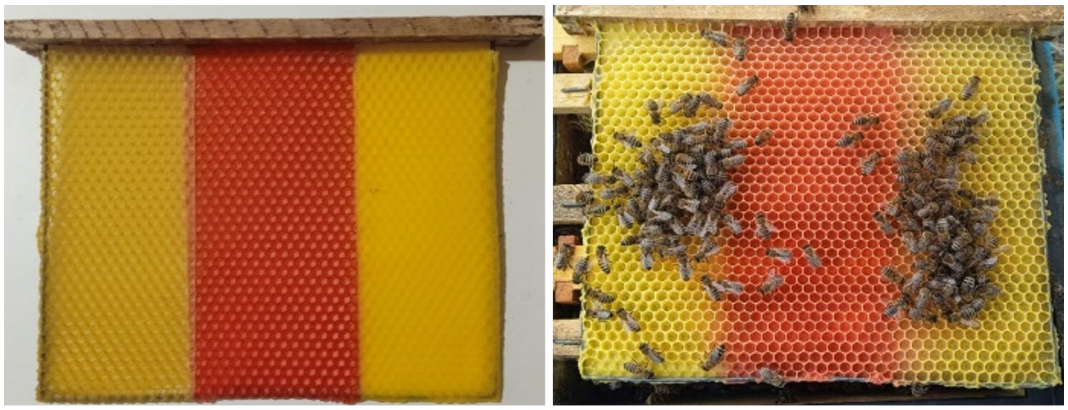


Figure 6. *Artificial honeycombs made of:*
a - simple artificial honeycomb, b - coloured honeycomb, c- honeycomb from capping

Honeycombs are constructed vertically from top to bottom and on both sides of the foundation sheet. Their thickness in the central brood area is approximately 25 mm, whereas in the upper part of the comb, where honey is stored, it may reach 37–45 mm or even more when the space between combs is intentionally increased. The honeycomb structure is highly resistant because each cell wall is shared by six adjacent cells, and the base of each cell is common to three cells on the opposite side. Newly built combs are semi-transparent, but once filled with honey, they can support a weight of 3.5–4.0 kg or more.

Newly constructed combs are light yellow in colour. Figure 4 presents the combs formed on simple wax foundations, capping wax foundations and traditional wax foundations.

The research has shown that the worker bees give priority to the construction of cells from capping and simple combs compared to the traditional ones.

When introducing the frame with the portion of coloured comb and traditional comb (Figure 7), after a day of maintenance in the nest, the bees started the construction of the portion of coloured comb, and the traditional one remained untouched.

Figure 7. *Artificial honeycomb accepted for construction consisting of portions: traditional honeycomb, honeycomb from capping, and simple honeycomb*

The frames with sections of coloured, traditional combs from capping and the frame with sections of simple, coloured combs from capping after one week were built differently. The frames with coloured artificial combs in the process of building cells by worker bees are presented in figure 8 the artificial combs, the level of cell construction, the queen in the process of laying eggs and the process of raising uncapped and capped brood.

Figure 8. *Queen in the process of laying eggs and raising brood in artificial combs*

Thus, it was found out that the level of acceptance of the type of comb and cell formation by the bees was different, namely: newly built combs have a light -yellow colour, worker bees give priority to the construction of cells from capping and to the simple ones compared to the traditional ones, the artificially coloured comb was given priority by the worker bees and was accepted for cell growth compared to the simple and traditional combs, the worker bees built the cells of the coloured beehive keeping the red colour, in the portion of the traditional comb fewer cells were built, the wax capping combs (ecological) are the most accepted for cell formation by the bees.

CONCLUSIONS

Following the assessment of the intensity of acceptance and cell formation by bees of different types of artificial combs: coloured, simple, ecological, and traditional, it was revealed that the newly built combs have a light- yellow colour, the worker bees give priority to the construction of cells from the comb from capping and the simple one compared to the traditional one.

The worker bees gave priority to the coloured artificial comb, and it was accepted for cell growth, maintaining the red colour compared to the simple and traditional combs. The artificial combs from wax capping (ecological) are the most accepted for cell formation by bees and the construction of combs.

ACKNOWLEDGEMENTS

The research was carried out with the financial support of the institutional applied research project “Development and implementation of good practices for sustainable agriculture and climate resilience (GREEN)”, Subprogramme Code 020407, funded by the National Agency for Research and Development of the Republic of Moldova.

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Conflict of interests
No competing interests were disclosed.

Paper history
Received 25.04.2026; Accepted 10.06.2026.