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TECHNOLOGY OF INDUSTRIAL PRODUCTION OF BEE PATTIES

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ABSTRACT

Beekeeping is a vital economic and traditional practice with significant economic and ecological impacts. Beyond producing functional and medicinally beneficial products for humans, honey bees (*Apis mellifera*) play a crucial role in plant pollination - a service with an economic value far exceeding that of bee products. Supplemental feeding using industrially produced foods, such as sugar syrups and protein patties, is essential for ensuring adequate winter food supplies. Protein patties are typically produced using integrated sugar products and dried yeasts (for bakery and livestock use), enriched with proteins, vitamins, minerals, and nutritional bio stimulants. This technologically advanced production process involves the careful selection of raw materials, storage, refining, grinding, heat treatment, dosing, homogenization, fat addition, packing, and transportation. Strict quality control at every stage ensures the final product meets the nutritional needs of bees and the expectations of beekeepers. This study analyzed honey yields over five years in two apiaries. Case Study 1 recorded a total honey yield of 9,400 kg, while Case Study 2 yielded 2,550 kg. The results highlighted the positive impact of stimulatory supplements on bee productivity, with particularly notable improvements in 2021 and 2022. Additionally, local environmental conditions were found to significantly influence honey yields. The findings confirm that stimulatory supplements enhance bee activity, immunity, queen productivity, and the successful wintering of young bees. These advancements demonstrate the potential to improve the sustainability and productivity of beekeeping through targeted nutritional interventions.

Keywords: bee families, stimulant feeding, bee patties, industry, honey yield.

INTRODUCTION

Beekeeping is a significant agricultural sector in Macedonia, supported by its favorable climate, diverse flora, and long-standing traditions. The country's geographical and ecological diversity provides continuous foraging opportunities, enabling high productivity of

bee colonies (Hatjina et al., 2014). Globally, beekeeping practices vary considerably. In regions with unfavorable climates, such as Scandinavia, the focus is primarily on pollination services. In contrast, countries like Russia, the United States, and China have developed advanced beekeeping industries incorporating modern technologies (IPBES, 2016). The sustainable development of this sector depends on protecting natural resources and adopting innovative technologies (FAO, 2020). Honey bees (*Apis mellifera*) play an essential role in pollination, contributing to the productivity of approximately one-third of global agricultural crops. However, in Macedonia, climate change is increasingly disrupting beekeeping through extreme weather events, reduced availability of nectar-producing flora, and declining bee populations. Shifts in temperature and precipitation patterns directly impact the health and productivity of bee colonies (FAO, 2017). Over the past two decades, these climatic changes have become more pronounced, characterized by rising temperatures, reduced precipitation, and more frequent extreme weather conditions. These challenges affect not only crop yields but also beekeeping productivity, emphasizing the critical need for adaptive practices and technologies to mitigate their adverse effects. The rising temperatures and shifts in vegetation periods reduce the availability of pollen and nectar, adversely affecting bee nutrition and immune systems. Proper preparation for wintering is crucial for the successful survival and development of bee colonies in spring. The scarcity of natural pollen in autumn, often driven by climate change, necessitates supplemental feeding. Stimulant feeding promotes brood development and enhances bees' physiological readiness for the early spring nectar flow (Ricigliano et al., 2021). Climate-induced factors, such as premature plant flowering and extreme weather events, increase the reliance on industrially produced food. These disruptions often lead to a mismatch between bee activity and natural food availability, weakening colony development (Landaverde et al., 2023). Properly administered stimulant feeding ensures a balanced diet, essential for normal bee development and successful wintering. Protein reserves in hives are particularly critical for maintaining healthy broods during winter and early spring (Topal et al., 2022). The absence of adequate protein reserves can severely limit brood development, directly impacting the productivity and vitality of bee colonies. Insufficient pollen and nectar availability in early spring or during unfavorable climatic conditions adversely affects queen activity and colony size, leading to reduced honey yields and weakened vitality (Standifer et al., 1980; Brodschneider & Crailsheim, 2010). Protein nutrition is critical for the growth and development of bees. High-quality protein patties are created using combinations of skim soy flour, dry yeast, sugar, water, vitamin C, and skim milk powder (DeGrandi-Hoffman et al., 2016). Adding 10–12% pollen to these patties enhances their composition, supplying essential nutrients required for bee health and vitality (Somerville, 2005; Bogdanov, 2012).

Carbohydrate nutrition forms the foundation of energy supply for bees. Sugar patties (made from cane or beet sugar) or sugar syrup serve as effective substitutes for natural nectar sources, enabling the continuous growth and productivity of colonies (Mattila & Otis, 2006). Water is another essential component for the physiology, growth, and development of bee colonies. A lack of water can significantly impair bee behavior and productivity. Providing a constant supply of clean, potable water—either from natural sources or through artificial containers—is crucial to maintaining strong and healthy colonies (Seeley, 1995). Medicines for disease control, such as treatments for Nosemosis, can be incorporated into the patties. However, they should not be administered at least five days before the start of honey collection to avoid contamination of the honey (Ricigliano et al., 2022).

Industrial production of animal and bee feed

Yeast in animal nutrition and its role as a supplement

Yeast (*Saccharomyces cerevisiae*) is a valuable supplement in livestock nutrition due to its high nutritional content, including proteins of high biological value, B vitamins, minerals, and polysaccharides such as β -glucans and mannans. Its inclusion in animal diets enhances nutrient absorption, modulates immune responses, reduces digestive tract pH, and promotes growth.

Biostimulants in bee nutrition

During periods without natural forage, bio stimulants in the form of powdered supplements enrich bee diets with essential nutrients. These formulations typically combine dried yeasts, skimmed milk powder, vitamin C, minerals, and vitamins, serving as effective substitutes for pollen. With their high biological and nutritional value, these supplements provide proteins, fats, and other critical components that enhance the vitality and productivity of bee colonies (Kwakman & Zaat, 2012; Mattila & Otis, 2006).

Objectives of the research

Beekeeping practices often incorporate stimulant supplements, influenced by factors such as weather conditions, natural forage availability, apiary location, financial resources, and time constraints. This study aims to describe the technological process for producing bee patties using a conventional approach rooted in Fordism-a system of labor rationalization. It provides a detailed definition of the raw material composition and the production technology of bee patties.

The primary objective was to evaluate honey yield over the past five years, both in total and per hive (bee family), when stimulant feed (bee patties) was used during periods of limited natural forage and insufficient hive honey stores.

Research materials and methodology

The production process follows traditional methods that have been practiced for over 35 years at the "Yeast and Alcohol Factory" in Bitola. The research also examines the rationalization of this process through handmade techniques, incorporating Fordism as a labor optimization system.

A sugar pattie is defined as a dough-like product with a light to dark cream color. Its basic composition includes water and sugar (sucrose), supplemented by dry baker's yeast (SAK), skimmed soy flour, skimmed milk powder (maximum 1.25% fat), vitamin C (ascorbic acid) in minimal concentrations, and a carefully dosed solution of hydrochloric acid (HCl) and sodium bicarbonate (NaHCO_3).

The production process involves several technological operations, culminating in the cooling or hardening stage, resulting in a compact, homogeneous dough. In small concentrations, the pattie also contains B vitamins (B1-thiamine, B2-riboflavin, B3-niacin, B5-pantothenic acid, B6-pyridoxine, and B7-biotin) as well as essential macroelements (potassium, calcium, magnesium, and sulfur) and trace elements (zinc and copper), primarily derived from the yeast (Table 1).

Table 1. Average nutritional value of bee pattie

Average nutritional value	100 g
Energy value 100 g / kJ	1732
Carbohydrates (g)	102
Protein (g)	2
Fat (g)	0.5
Ash (mineral matter) (g)	0.04

Materials and equipment used in the manufacturing process

The production of bee patties involves a series of mechanical procedures to ensure product consistency and quality. The process begins with grinding sugar into fine granules using a mill. The biostimulator is mixed in a mixer, while sugar is measured with a heavy-duty scale. Mixing is performed manually using a wooden stirrer or spoon, or mechanically with stirrers placed over a cauldron duplicator. The mixture is emptied with a plastic spatula and placed into molds lined with polyethylene bags. A vacuum machine seals the bags, and wooden rolling pins are used to iron them flat. To remove trapped air, the bags are pierced with needles. The mixture's temperature is measured with a thermometer, acids are dosed with a glass test tube, and soda is dissolved and dosed using laboratory glassware. Samples are placed on a grid to test for leakage, which is then analyzed further in an oven incubator. A high-precision analytical balance is used for all quality checks. This production process combines traditional methods with modern tools to maintain consistency and meet quality standards.

RESULTS AND DISCUSSION

Analysis and assessment of the technological process for obtaining bee patties

The technological process for producing bee patties consists of several mechanical procedures designed to ensure smooth operation and optimal efficiency at each stage. The process begins with the preparation of raw materials. The sugar is ground in a machine-mill to obtain a fine, uniform granulation, which is crucial for proper absorption in the bees' digestive system. If the sugar granulation is too coarse, bees are likely to reject it as a food source. After grinding, the sugar is weighed using a heavy-duty scale to ensure accurate dosing. Next, a mixture of water and ground sugar is prepared in a cauldron or open duplicator, heated to a temperature of 35–40°C. The sugar is stirred with a wooden spoon until fully dissolved, resulting in a homogeneous sugar syrup. In the following stage, hydrochloric acid (HCl) is added to the syrup, and the mixture is stirred intensely for about five minutes. The mixture is then left to stand for 10–15 minutes, allowing the components to fully combine and form a creamy, crystalline layer on the surface. Baking soda (NaHCO_3) is then added, and the mixture is stirred again for the same duration as before. After standing for another 10–15 minutes, a white, foamy layer forms on the surface, indicating that the chemical reactions have successfully occurred.

In parallel with the previous steps, the ground sugar is prepared in precise quantities to ensure the correct ratio of ingredients. This step is vital for achieving a consistent composition and structure in the final bee patties, ensuring that bees readily accept and consume them. After the addition of NaHCO_3 and allowing the mixture to stand, the

condensate is drained off. Then, the remaining ground sugar, along with the biostimulator mixture (dry yeast, skimmed soy flour, skimmed milk powder, and vitamin C), is incorporated. This mixture is prepared in the machine-mixer, as described earlier in the process.

Once the biostimulator is added, the mixture is subjected to low pasteurization, heating it to a temperature of 60–65°C, while being mixed continuously in the cauldron using stirrers. The mixing process lasts about 30 minutes, ensuring homogenous sugar dough. Properly mixed dough should exhibit excellent homogeneity and separate easily from the walls of the cauldron, indicating that this stage is complete. During mixing, preparations are made for transferring the mixture into molds. Polyethylene bags (nylons) are used to line them, with each bag stamped with a date. After the mixture is emptied into the molds, the bags are sealed using a vacuum machine to ensure airtight packaging. Once all are filled and sealed, the batch is moved to the final stage-ironing or kneading. This stage is crucial for shaping and finishing the product. Wooden rolling pins are used to knead, ensuring the desired shape, texture, and consistency. The result is high-quality patties that are well-formed, properly sealed, and ready for use in bee nutrition. If any air is trapped in the bag, it is removed by piercing the bags with a fine needle, allowing the air to be completely squeezed out. Once this procedure is completed, the kneaded loaves are placed on another work table to cool while waiting for the next batch from the cauldron. After cooling, the finished patties are packed into cardboard boxes weighing 10 or 15 kg, which are then arranged on pallets and marked with the preparation date. The packaged patties are ready for distribution and are stored at a temperature of up to 25°C in dry, dark rooms. Under these conditions, their shelf life is up to one year. The duplicator is a key element in this process. It is a hemispherical-shaped kettle (cauldron) made of stainless steel, with a casing placed on its lower side. A heated fluid, in the form of water vapor, is introduced into the space between the boiler and the casing, with the condensate flowing out through an opening. This steam is produced by our own boiler room and is also used in other production processes. The cauldron is emptied by rotating it around its axis, allowing the contents to be transferred easily and efficiently.

The finished bee patties are packed in cardboard packaging weighing 10 or 15 kg and arranged on pallets according to each batch (program) separately. The batches are classified as bio patties, sugar patties (basic, standard), and stimulant patties, with each batch placed on separate pallets (see Picture 1). When packed in this way, the patties have a shelf life of one year, provided they are stored at a temperature of up to 25°C in a dry, dark place. These storage conditions ensure the longevity and preservation of the product's quality.



Picture 1. Bio, sugar and stimulant cake

Evaluation of quality control measures and regulatory standards applied to bee food production

The technological process of bee patty production adheres to the regulations and decisions outlined in the *Regulation on Special Requirements for Food for Bees*, which defines the microbiological criteria for food, as adopted by the Food and Veterinary Agency (AHV). This regulation was published in the *Official Gazette of the Republic of North Macedonia* No. 100, dated 15.07.2013. Additionally, the *Regulations for General and Special Requirements for Food Safety for Animals*, published in the *Official Gazette of the Republic of North Macedonia* No. 157 of 2010, No. 53 of 2011, and No. 1 of 2012, align with the *Law on Food Safety*, ensuring that bee food production complies with established safety and quality standards.

Flaws and disadvantages of bee patties

One of the main flaws of bee patties is the organoleptic change in color that occurs during extended storage. Initially light cream in color, the patties darken over time, developing a caramel-like hue. This change is attributed to the presence of lactic acid ($C_3H_6O_3$), which forms when monosaccharides decompose under the influence of bases like sodium bicarbonate ($NaHCO_3$). Another significant disadvantage is the alteration in the consistency of the sugar dough, particularly when the mixture is heated above 65°C. At higher temperatures, the dough becomes rubbery, resulting in a stickier mixture. This increased stickiness causes difficulties during the molding process, making it harder to pour the mixture into the molds. Additionally, the patties become more difficult to knead, and the final product tends to be more prone to dripping.

Results of case studies

The main goal of the research was to determine the honey yield over the past five years among beekeepers who use stimulating food, specifically bee patties produced by AD Kvasara, Bitola. To achieve this, research was conducted at several apiary locations to assess how stimulant feeding affects the health and immunity of bee colonies, their activity, queen laying, bee productivity, reproduction, and successful wintering. According to the statements of beekeepers, feeding bees from wintering to spring grazing had a positive impact, particularly on the strength of bee colonies and honey production during the 2019-2023 period.

Case study 1: "Apiary R"

The first research was conducted at an apiary near the village of Rotino, in the municipality of Bitola, situated at an altitude of 1014 meters, nestled in the foothills of Mountain "Baba". Over the last five years, the total honey production amounted to approximately 9400 kg.

Table 2. Honey yield in the last five years, in total and per hive, apiary in village Rotino

Year	Number of hives with bee families	Honey yield (kg)	Average honey yield per hive (kg)
2019	150	1500	10
2020	150	1200	8
2021	150	2200	15
2022	150	2500	17
2023	150	2000	13
Total honey in kg		9400	/

Case study 2: "Apiary K"

The second research was conducted at an apiary in the village of Krklino, located at an altitude of 597 meters in the Pelagonia region. The apiary consisted of 40-45 hives with bee colonies. The aim of the research was to analyze honey yield and the effect of stimulating feeding on the productivity and health of the bee colonies.

Table 3. Honey yield in the last five years, in total and per hive, apiary in village Krklino

Year	Number of hives with bee families	Honey yield (kg)	Average honey yield per hive (kg)
2019	44	450	10
2020	40	300	7.5
2021	45	600	13
2022	45	800	18
2023	42	400	9.5
Total honey in kg		2550	/

The average honey yield per hive in the apiary in the village of Krklino ranged from 7.5 kg in 2020 to 18 kg in 2022. The highest yield was recorded in 2022, when climatic conditions and natural grazing were most favorable. Over the last five years, the total honey production amounted to 2550 kg. The highest average yield occurred in 2022 (18 kg per hive), while the lowest was in 2020 (8 kg per hive), which is related to unfavorable climatic conditions. According to statements from the beekeepers, the use of the stimulating supplement in the form of bee patties produced by AD Kvasara, Bitola, had a significant impact on the health and activity of the bee colonies, especially in years with limited natural sources of nectar and pollen. This supplement helped maintain strong and healthy bee families, which is of particular importance in conditions of scarce natural resources and the influence of climatic conditions. The highest honey yields were recorded in 2021 and 2022. Our results align with worldwide research that confirms stimulating nutrition helps minimize the effects of seasonal changes and adverse climatic conditions. The results of Standifer (1980) and Tawfik et al. (2020) indicate that bee patties improve the health of bees, enhance their immunity, and facilitate wintering, especially in areas with cold winters and limited natural grazing. According to Collazo et al. (2021), proper application of stimulatory feeding

aids in the prolonged laying of the queen and maintaining a stable bee population, which is key to fostering strong bee colonies. Based on the results, stimulatory feeding with bee patties represents a key intervention for apiaries with limited natural pasture, confirming the need for adapted feeding strategies in beekeeping.

CONCLUSION

Modern beekeeping, in addition to honey production, increasingly focuses on aspects such as the growth, development, productivity, reproduction, and successful wintering of bees, as well as their resistance to diseases. These factors become especially important in conditions of limited natural pasture and honey shortages in hives. Stimulating food, which compensates for the lack of natural pollen, plays a key role in maintaining healthy and productive bee colonies. The analysis of the composition and production process of the bee patty confirms its high nutritional value. The formulation, which includes sugars, vitamins, minerals, and yeast, significantly contributes to the health and productivity of bees. The production process is technologically advanced and strictly controlled, from the preparation of raw materials to final packaging, ensuring the quality and suitability of the food for the needs of beekeepers and bees. The results of the research confirm that the stimulating food has a positive effect on bee activity, immunity, queen productivity, and the successful wintering of young bees. By applying such approaches, beekeeping can strengthen its sustainability and productivity in the future.

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