Krakow Review of Economics and Management
Zeszyty Naukowe Uniwersytet Ekonomiczny w Krakowie
3 (1013)
2026

KREM, 2026, 3(1013): 5–23
ISSN 1898-6447
e-ISSN 2545-3238
https://doi.org/10.15678/krem.18831

A PESTLE Analysis of the Polish Honey Market

Igor Olech[1], **Artur Olech**[2]

[1] The Institute of Agricultural and Food Economics – National Research Institute, Department of Agribusiness and Bioeconomy, Świętokrzyska 20, 00-002 Warszawa, Poland, e-mail: igor.olech@ierigz.waw.pl, ORCID: https://orcid.org/0000-0003-1920-8760

[2] ORCID: https://orcid.org/0009-0001-2180-9584

Suggested citation: Olech, I., & Olech, A. (2026). A PESTLE Analysis of the Polish Honey Market. *Krakow Review of Economics and Management / Zeszyty Naukowe Uniwersytetu Ekonomicznego w Krakowie*, 3(1013), 5–23. https://doi.org/10.15678/krem.18831

ABSTRACT

Objective: To conduct a multi-faceted analysis of the honey market in Poland within the context of functioning as part of the European Union. The analysis aims to identify key political, economic, social, technological, legal, and environmental determinants.

Research Design & Methods: The study employs the PESTLE method as an analytical tool to identify the factors influencing the beekeeping sector systematically. The analysis incorporates market reports, academic literature, and documents from both the EU and Poland.

Findings: The analysis revealed that the honey sector in Poland operates within an environment of significant export potential. It is influenced, among others, by the Common Agricultural Policy, climate, growing consumer expectations regarding product quality and origin, and the development of beekeeping technologies. Structural barriers and legislative constraints were also identified.

Implications/Recommendations: The results of the analysis suggest the need to strengthen the role of producer organisations, implement innovative technologies in apiaries, and increase the sector's integration with the EU's pro-environmental policies. The article highlights the low level of consumer education and promotion of honey as a high-value-added product.

Contribution: The article offers practical conclusions for policymakers, industry organisations, and honey producers, pointing to potential development directions for the sector in the context of a sustainable agri-food economy.

Article type: original article.

Keywords: apiculture, beekeeping, honey, Poland, European Union, PESTLE.

JEL Classification: Q13.

1. Introduction

Poland is a significant honey producer in Europe, annually placing itself among the top 10 honey-producing countries (Pawłowska-Tyszko, Jarka & Olech, 2024), granting stability to the honey market in the EU, despite its lower internal consumption levels, as compared to many others, especially "old" EU member states (Kowalczuk, Jeżewska-Zychowicz & Trafiałek, 2017; Pawłowska-Tyszko, Jarka & Olech, 2024). Besides a wide variety of honey production in Poland (Starowicz *et al*., 2021), apiculture also produces other outputs, such as propolis, bee wax, and pollen (Maciejczak, Olech & Kalinka, 2023), as well as provides ecosystem services, such as pollination (Majewski, 2014; Piechowicz *et al*., 2022), increasing food security and agricultural resilience (Pawłowska-Tyszko, Jarka & Olech, 2024). Honey also has health benefits due to its nutrient richness and antioxidative properties (Grecka *et al*., 2018; Halagarda *et al*., 2020). The study by Kowalczuk *et al*. (2023) on the honey consumption in Poland reports that 90% of their survey respondents consume honey, while during the time of the COVID-19 pandemic, 34% of respondents admitted to increased honey consumption.

Thus, the honey market is an increasingly relevant topic for research, beyond economic considerations, reaching toward its environmental and social functions. This article investigates in an integrated way different factors influencing the honey industry in Poland and compares them to two other studies investigating their national honey markets using the PESTLE method, namely India and Ethiopia. Although these markets seem distant and very different from the Polish one, it is interesting for the overview of this sector, and to compare different incentives and obstacles which rule it. The goal of this article is to assess the relevance of different factors shaping the Polish honey market.

2. Method

The application of the PESTLE method allows for the broad analysis of factors impacting the dynamics of certain phenomena (Boratyńska, 2025). The method divides these factors into six factors, which are Political (P), Economic (E),

Social (S), Technological (T), Legal (L), and Environmental (E). It allows for the assessment of such potential threats as political stability (Zalengera *et al*., 2014), changes in consumer behaviour (Hamzah & Anggoro, 2023), or technological adoption (Thomas *et al*., 2021; Singh, Jatav & Pasumarti, 2025). Through the lens of these factors, this article analyses the honey sector in Poland. To enhance the analysis, the qualitative analysis of the literature was supplemented by the indices, which help to understand the situation of the beekeeping industry in Poland.

Most prior studies on honey use either single-factor risk assessments. An application of PESTLE (Political, Economic, Social, Technological, Legal and Environmental) offers a sharper view of the forces shaping the sector. Comparable PESTLE studies already exist for Ethiopia's southwest highlands (Bayissa *et al*., 2024) and India (Narang, Kumar & Gupta, 2022). The outcomes of these studies were confronted with the analysis of the situation of Polish beekeeping.

3. Results

3.1. Political Factors

Although government subsidies for beekeepers precede Polish accession to the EU, Poland's access to the EU allowed Polish beekeepers to receive more expanded EU payments. Before the Polish access in 2004, Polish beekeepers were receiving funds from the Agricultural Market Agency (Agencja Rynku Rolnego), which existed in the years 1990–2017. Before the EU access, beekeepers were receiving funds for apiary equipment, combating pests, and the beekeeping organisations' support. EU access allowed beekeepers to use funds for further purchases, such as educational workshops, bee queens, or honey analysis, allowing for the improvement of the honey quality and food safety, and supporting beekeepers' income altogether. In 2023, Polish beekeepers utilised 86.9% of the funds dedicated to them from the Common Agricultural Policy (CAP) funds, being 10th regarding the rate of funds utilisation in the EU (average utilisation rate was at 77%). After Romania, Spain, and Greece, Poland received the largest amount of EU funds for beekeeping, i.e. 4.368 bn euro (European Commission, 2023). The EU's ambition of creating sustainable agriculture intertwines political, economic, and environmental factors, as EU-created regulations not only target the economic performance of apiaries but also address ecological concerns, enhancing biodiversity and ecosystem resilience. Conversely, although subsidies can temporarily increase productivity, they can also make apiaries dependent on them, curbing their long-term efficiency, as was observed in other sectors (see: Pisulewski & Marzec, 2022).

Next to the EU initiatives, national ones have also been established, such as the National Breeding Association in 2019, with a goal of breeding practices improvement in Polish apiculture and its management (Bieńkowska, Łoś & Węgrzynowicz,

2020). The beekeeping landscape was also significantly impacted by the COVID-19 pandemic, due to the limited market exposure (Maciejczak, Olech & Kalinka, 2023). Thus, beekeeping also requires more comprehensive support systems in case of an unexpected crisis.

3.2. Economic Factors

The economic factors in the honey industry (similarly to other industries) depend on market supply and demand (and thus prices), the costs of production, and the overall economic situation. Poland has a significant role in the EU honey trade, reflecting its overall position in the agri-food sector. Since Poland joined the EU, it has increased its production as well as export capacity, due to the EU internal market as well as production standards harmonisation (Bajan, Łukasiewicz & Smutka, 2021; Pasimeni, 2021). Although the forecast for the Compound Average Growth Rate (CAGR) for the years 2024–2028 of the industry is at 2.04% (ReportLinker, 2023a), Poland is still reliant on honey imports (especially from China and Ukraine), with only ca. 60–70% self-sufficiency in this product (Pawłowska-Tyszko, Jarka & Olech, 2024). Specific standards grant consumer confidence in Polish honey also among the "old" EU countries, thus increasing export possibilities (Dluhošová *et al*., 2018).

Consumer choices shift towards organic honey not only due to its taste but also due to its health benefits, both in traditional and conventional medicine (Pellissery, Raja & James, 2012), such as anti-inflammatory and anti-microbial properties (Soares *et al*., 2017). This shift is caused by the overall trend of natural and non-processed food consumption (Mancuso, Croce & Vercelli, 2020). On the supply side, the prices of honey are highly influenced by the production equipment (bee hives, honey extractors, etc.), bee feed (as during the winter bees require additional feeding with sugar or honey), and labour costs. The implementation of sustainable practices, which enhance honey properties, may cause additional costs to the production and to its final cost (Çevrimli & Sakarya, 2019).

The honey consumption is affected by the overall economic situation. It is a premium product (Pawłowska-Tyszko, Jarka & Olech, 2024), and possible economic fluctuations can affect consumers' willingness to pay higher prices, especially for more expensive organic honey (Athari *et al*., 2022). For instance, during the COVID-19 pandemic, prices have increased by ca. 15%. According to Tultabayeva *et al*. (2023), honey prices are relatively inelastic in the short term, i.e. consumers are less sensitive to their changes, which may lead to persistent periods of low prices that may not cover production costs, negatively affecting the sustainability of honey production, especially in smaller apiaries.

The marketing of Polish honey may be enhanced by branding its qualities, such as local origin and production methods, to capitalise on the health-consciousness

and food quality trends (Haryadi *et al*., 2022). For some kinds of honey, the labelling is especially relevant, as it signifies their specific origin, and is especially relevant for such Polish kinds of honey as buckwheat and rapeseed varieties (Puścion-Jakubik *et al*., 2022). The average yield per colony is decreasing, as an increasing amount of beekeepers are hobbyist small-holders. As Żuchowski and Olszewski (2023) point out, the increase in the number of beekeepers does not have to translate to a higher amount of apiary production, as is the case in Poland.

3.3. Social Factors

Historically, honey has been used in Poland both in the cuisine and in traditional medicine. For the latter reason, a higher demand can be typically observed during the cold winter months, as remedies, but also during traditional celebrations (Tkachenko *et al*., 2023). Thus, traditionally, both festive and medicinal functions of honey reinforce each other. A further significant shift in Polish honey consumption patterns occurred in the 1980s, when in the period of sugar scarcity honey was treated as its substitute, although the current shift is mainly fuelled by the health concerns of the consumers (Kowalczuk, Jeżewska-Zychowicz & Trafiałek, 2017), e.g., during the COVID-19 pandemic, when the honey consumption substantially increased (Olech & Olech, 2024). Overall, the honey consumption in Poland is lower than in Western EU countries, and is highly seasonal, with increases during the cold months.

The shift in consumer preferences is marked by the rising willingness to pay for premium products, e.g., those that display a quality label (Kowalczuk, Jeżewska-Zychowicz & Trafiałek, 2017; Gajda *et al*., 2018). This poses a challenge for the beekeepers to fulfil specific requirements needed to obtain such labels, but if obtained, it signals to consumers the adherence to sustainable practices, such as avoidance of chemical agents in favour of natural apiary practices (Suhri & Bahar, 2023). Poland can market some local kinds of honey, which are labelled on the EU level, allowing foreign consumers to diversify (Bajan, Łukasiewicz & Smutka, 2021; Pawlak & Smutka, 2022). Besides raising standards and quality, it is also possible due to the strategic location of Poland within the EU (Szczepaniak, 2018).

Besides traditional, festive, and medicinal applications regarding social factors influencing the Polish honey market, there are also educational efforts to increase the societal knowledge of honey. These may be both consumer education, such as awareness campaigns, as well as beekeeper education through workshops, which increase their competencies (Kowalczuk, Jeżewska-Zychowicz & Trafiałek, 2017). The awareness campaigns not only contribute positively to society by increasing honey consumption, but also contribute to the overall trend of environmental protection and responsible consumption (Wróblewska & Stawiarz, 2015). These, in turn, are reinforced through novel information technologies. The shift in consumer

demand is also influenced by the technological shift in modern society, in which social media shapes consumer preferences, e.g., with the spread of health consciousness, both in Poland as well as in other countries (Kowalczuk, Jeżewska-Zychowicz & Trafiałek, 2017).

3.4. Technological Factors

Technology may foster the bee hive's productivity, and thus its profitability. Some support the monitoring of the bee hives and their real-time performance, the health of the colonies (temperature, humidity, the presence of pests, etc.), and the so-called smart hives (Kurdin & Kurdina, 2025), expanded by the quality control mechanisms. It allows to keep the high trust of the consumers in the product and its quality (Kocot *et al*., 2018).

The honey producers can increase their margin by offering the sale of their produce through new sales channels such as e-commerce, omitting the middlemen, who often take significant compensation for the produce distribution. Such sales channels can further increase the market margins of the apiaries with the further increase of digital literacy in society. The new marketing channels also include social media, allowing small-scale apiaries to increase their market exposure (Nurleli *et al*., 2023). Market exposure to bee products can be obtained through marketing bee products, such as bee bread, although the cost of certain technologies may not be justified in smaller apiaries (Semkiw & Skubida, 2021).

Table 1. Beekeeping Financing from CAP MFF, 2023–2027

Policy	Description of the Intervention in the Beekeeping Sector	Fiscal Year 2024 (Million Euro)
INVAPI	Technical assistance and support for the modernisation of apiary farms	2.063
	Supporting the fight against varroosis with medicinal products	1.605
PRESBEEHIVES	Aid for the reconstruction and improvement of the utility value of bees	0.699

Source: own study, based on (Ministry of Agriculture and Rural Development, 2024)

The technological factors in Poland are strongly connected to the political ones, as Poland has strongly participated in the CAP apiary projects which enhance the technological development of this industry (Table 1). These were the only two programmes (out of seven) in which Poland has participated. Poland did not participate in other projects, which included, e.g., support for the marketing of bee products and cooperative action among beekeepers (European Commission, 2023).

It also shows the strong dedication of the policymakers to improve the technological side of beekeeping, as well as to diminish the threats to the existing apiaries.

3.5. Legal Factors

According to internationally agreed-upon Codex Alimentarius regulations, honey is a natural substance originating from flowers or other living parts of plants, processed by bees. EU regulations set criteria requiring honey to be pure and to have specific physicochemical properties, such as moisture and diastase activity (Naila *et al*., 2021), and to be free from additional substances (Calle *et al*., 2021), such as heavy metals, antibiotics, or pesticide residues with the maximum residue limits, although specific limits for bee products are not fully developed (Gałczyńska *et al*., 2021; Scripcă & Amariei, 2021; Rodrigues *et al*., 2024). Besides the honey content rules, the EU encourages the adoption of environmentally friendly practices in beekeeping, offering financial support and outreach programmes, with the goal of industries' financial support and maintenance of the natural environment, besides improving the well-being of the bees (Kazazić & Mehić, 2024), by e.g., limiting the impacts of extreme weather events or invasive species (Kagiali *et al*., 2023).

The aim of the quality regulations is to protect honey from adulteration, which negatively affects consumer confidence (Kek *et al*., 2017) as well as the reputation of the sector and thus honey prices (Singh & Singh, 2018; Calle *et al*., 2021). Adulterated honey is sold at lower prices than unadulterated honey, but affects the honey demand in the long run, causing price fluctuations (Fakhlaei *et al*., 2020). The research of Kędzierska-Matysek *et al*. (2022) shows that the honey from south-eastern Poland passes the required quality tests.

Another relevant legal factor is the zoning law, which establishes where bee hives can be placed, e.g., their distance from residential areas (Ligor, Kowalkowski & Buszewski, 2022), by mitigating potential threats of the bee hives towards people. These laws emerged as an answer to the increasing popularity of urban apiaries, as well as the increasing urbanisation of the EU and the rising trend of urban gardening (Tarapatskyy *et al*., 2021). These hives also require careful safety monitoring, as even in the urban setting, some bees can reach agricultural areas, where pesticides are used, and can impact the quality of honey (Dicks *et al*., 2012; Kędzierska-Matysek *et al*., 2022).

3.6. Environmental Factors

The honey industry can be significantly impacted by changing weather conditions, such as the alteration of seasonal patterns. First, it requires beekeepers to adjust their learned management practices (Al-Ghamdi *et al*., 2017). Second, although mild winters, which occur in Poland in the 21st century, can be beneficial

for beehives, extreme heat, and droughts can impact bees' ability to forage and produce honey, as reported in some research (see: Delgado *et al*., 2012; Quinlan, Miller & Grozinger, 2023), as well as beehives' productivity (Messeri *et al*., 2024). According to ReportLinker (2023b), the projected CAGR of natural honey in the years 2024–2028 is to be 1.53%, thus being lower than the overall honey industry growth at 2.04% in the same period. Moreover, bee hives can be affected by heavy rains, limiting the availability of the hive to explore its surroundings, as well as disrupting the plant flowering, thus limiting the ability of the nectar collection (Park & Nieh, 2017; Malagnini *et al*., 2022).

The potential losses can be mitigated by the implementation of sustainable beekeeping practices, such as feeding the bee hives during the periods lacking an adequate amount of feed, rotating the locations of the bee hives depending on the season and plants, and implementing integrated pest management (Kumsa & Takele, 2014; Taha & Al-Kahtani, 2019; Tarekegn *et al*., 2022).

4. Discussion

As with any other industry, Polish honey is impacted by political, economic, social, technological, legal, and environmental factors, and none of these is isolated (Fig. 1).

Two other studies have been identified, which analyse their national beekeeping industries: one analysing India (Narang, Kumar & Gupta, 2022) and Ethiopia (Bayissa *et al*., 2024). Although these countries present a significantly different profile from Poland, the beekeeping industries were compared to identify these differences, and the analysis was performed factor-by-factor.

As per the political factors, Poland benefits from clear EU residue rules and investment aid for apiary modernisation (European Commission, 2023), as well as from the newer national policies (Bieńkowska, Łoś & Węgrzynowicz, 2020), which can support the producers in the times of the times of instability (Maciejczak, Olech & Kalinka, 2024), as a crisis buffer. By contrast, Ethiopia still lacks a dedicated honey-marketing law, hampering quality control (Bayissa *et al*., 2024). India's National Bee Board (NBB) provides subsidies, but uneven state-level delivery limits impact (Narang, Kumar & Gupta, 2022). Thus, the dedicated legislation accelerates technology diffusion and export readiness; absence or fragmentation stalls value capture.

From the economic perspective, EU-level self-sufficiency hovers below 60%, sustaining premium import demand (Pawłowska-Tyszko, Jarka & Olech, 2024), whereas India projects double-digit growth, framing beekeeping as a rural entrepreneurship engine (Narang, Kumar & Gupta, 2022). Ethiopia's cost of modern hives and credit shortages cap productivity despite favourable ecology (Bayissa *et al*., 2024). Poland's diversified export outlets could hedge against price swings.

The quality harmonisation allows Polish honey to enter demanding Western markets (Bajan, Łukasiewicz & Smutka, 2021), as the consumer confidence in the Polish honey can be high (Dluhošová *et al*., 2018). Poland imports mainly for price-blend, although even the capacity of the Polish consumers to pay for premium honey products is increasing (Pawłowska-Tyszko, Jarka & Olech, 2024).

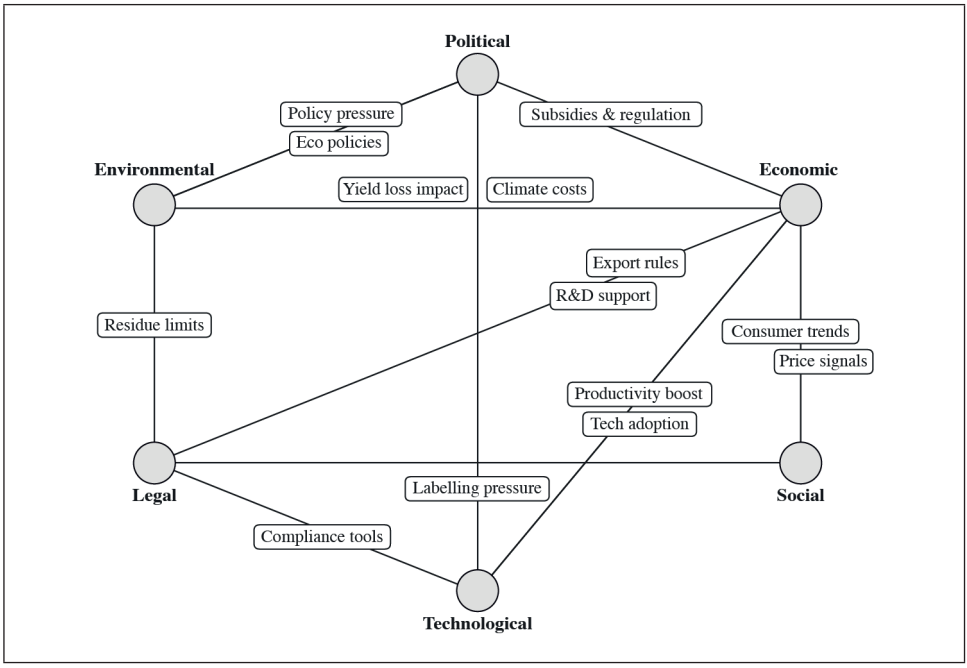

Fig. 1. PESTLE Interdependencies of the Polish Honey Market
Source: own study.

From the social standpoint, consumer trust in origin labelling underpins Poland's premium honey niche (Gajda *et al*., 2018). Moreover, the overall consumption is increasing due to the changing consciousness on health (Kowalczuk, Jeżewska-Zychowicz & Trafiałek, 2017) – aside from a significant growth due to the COVID-19 pandemic, but also including it (Olech & Olech, 2024) – as well as growing trends of the responsible consumption (Wróblewska & Stawiarz, 2015). Ethiopian smallholders channel most crude honey into local beverages (the so-called *tej*, or *birz*), limiting value addition (Bayissa *et al*., 2024). India frames beekeeping as youth employment and women's empowerment (Narang, Kumar & Gupta, 2022), while Poland's growth comes from retirees seeking ecological hobbies – both expand keeper numbers but with different labour economics. These rather distant societal factors show how cultural patterns mediate economic outcomes.

Technological solutions are applied differently in the studied countries. Poland channels the highest national envelope of the EU apiculture budget into equipment aid and eco-scheme bonuses for bee forage (European Commission, 2023), as the technological application in apiaries expand within the EU – an EU-wide survey (n = 844) states, that 20.9% of keepers use at least one digital monitoring device, with the adoption exceeding 40% among professionals (Verbeke *et al*., 2024). Worth mentioning are also innovative honey products, e.g., honey bread (Semkiw & Skubida, 2021). In India, the technological development is fostered mainly by the use of digital applications, which support the beekeepers (Narang, Kumar & Gupta, 2022), while the lack of widespread investments in technological solutions hampers the development of the industry in Ethiopia (Bayissa *et al*., 2024).

Legal uniformity of the EU is significant for the Polish beekeeping industry, as residue-limit directives demand rigorous testing from Polish (e.g., Gałczyńska *et al*., 2021). India, conversely, has different legal frameworks for the honey industry in different provinces, which is the exact opposite of the EU legal uniformity (Narang, Kumar & Gupta, 2022). Ethiopia again lacks a honey-marketing legal framework, opening space for adulteration and non-certified honey trade (Bayissa *et al*., 2024).

Environment-induced forage stress is ubiquitous for all of the analysed countries, but regional stressors differ. Ethiopia cites uncontrolled agro-chemical use and predator attacks, as well as the consequences of deforestation. India voices concern over electromagnetic radiation from mobile towers affecting bee navigation (Narang, Kumar & Gupta, 2022), and similarly, as in Ethiopia, its bee colonies suffer from the chemical pesticide use by farmers (Bayissa *et al*., 2024). In the Polish sources, predominantly the pesticide drift impacts the negatively the honey collection negatively (Kędzierska-Matysek *et al*., 2022). Thus, the pesticide use may be a widespread problem.

The granular presentation of the PESTLE factors in the studied countries is presented in Table 2.

Table 2. Crucial PESTLE Factors among Different Honey-producing Countries

Studied Country	Political	Economic	Social	Technological	Legal	Environmental
Ethiopia	Favourable investment policy, but no honey--specific statute; governance gaps	Credit cost and scarcity of modern hives depress productivity	Honey is mainly processed for beverages, limiting added value	Modern hive uptake constrained by price; private investors own processing tech	No marketing framework; lack of quality labs fuels informal trade	Deforestation, chemical misuse, and predators shrink yields

Table 2 cnt'd

Studied Country	Political	Economic	Social	Technological	Legal	Environmental
India	Long-running policies keep entry barriers low	High domestic market growth, backed by export demand and credit lines	Beekeeping framed as youth & women entrepreneurship	Apps promoted through extension schemes	Local quality assurance; demand for insurance and transport rules	Pesticides, radiation blamed for colony decline
Poland	CAP eco--schemes & investment aid	Moderate growth; imports for price blend	Hobby boom	Potential for sensor hives adoption	Residue limits, vet certification	Pesticide drift around crops

Source: own study.

Table 3. The Comparison of PESTLE Factors between Different Countries Studied

Studied Country	Dominant PESTLE Drivers Reported	Notable Differences from Poland
Ethiopia	Economic (credit cost), technological (modern hive prices), legal (marketing law absence)	Policy voids and credit bottlenecks, unlike in Poland
India	Social (job creation), political (NBB support), environmental (pesticide drift, EM radiation)	Low-cost digital apps; emphasis on rural employment
Poland	Political (CAP eco-schemes, investment aid), technological (accredited labs)	Credit is easier in Ethiopia; stronger consumer trust than in India

Source: own study.

The financial support for the beekeepers allows them to develop their production methods, giving them a comparative advantage, which is further supported by the professional quality assurance services. CAP grants drive 47% of recorded investments, and with the further adoption of technological solutions, political and technological factors foster the development of the Polish beekeeping industry. Where dedicated honey laws exist (EU), technology scale-up is faster; in the absence of laws, plus high credit costs stall progress, as is the case of Ethiopia, while India focuses on the low-cost mobile application technologies, which support its beekeepers. Poland's PESTLE profile aligns with the broader evidence that policy clarity and technology affordability are the key levers for the sector. The EU rigorous residue-limit law restricts the market entry – a pattern Poland already

navigates under identical EU rules – keeping the quality of the honey high. Ethiopia offers the mirror image: high-impact economic constraints (expensive modern hives, scarce credit) and the legal vacuum of a missing honey-marketing act together stall technology diffusion. India confirms that strong state programmes support low-cost digital tools side-by-side (see Table 3).

5. Conclusion and Recommendation

As the EU CAP provides financial support, it also funds environmentally friendly practices and technological advancements. Polish apiculture utilised the majority of these funds (although not as much as nine other countries), meanwhile, such support can in the future cause overdependence of the sector on them. For now, these funds are channelled toward the protection of the bees from stressors, such as extreme weather events or pests, thus contributing to the supply of local honey to the EU market, as well as toward the technological development of this sector, improving its efficiency and ensuring the maintenance of the quality standards. Moreover, the EU provides uniform legal and institutional framework, supporting the stability of the market. The need for high-quality honey is also shaped by the consumer demand for organic, healthy products, creating a feedback loop of social and political demands, shaping the regulatory landscape, thus driving ecological practices, which mould the production economics. Thus, these feedback loops can reinforce or constrain each other, depending on individual features of producers (but also consumers) within the sector.

The factors influencing the Polish honey market have been compared with other studies, which use the PESTLE framework to investigate honey markets of other countries. Overall, there has been a strong reliance on institutional stability and the significant role of the technological development programmes. These programmes can also support the protection of the bee colonies from the factors damaging them, which is a problem for beekeepers around the world. Thus, policy makers should couple CAP equipment grants with performance-based eco-premiums that reward reduced pesticide drift. These payments could be targeted towards both beekeepers, as well as towards the farmers who use chemical protection for their plants. Moreover, Poland (and the EU broadly) could benefit from emulating India's low-cost digital-app roll-outs by negotiating group software licences and bundled training.

The Polish honey sector operates in a macro-environment where policy and technology are decisive leverage points, corroborating our initial hypothesis but only when flanked by supportive economic and social enablers. Cross-country comparisons reveal that dedicated legislation and affordable tech accelerate sector upgrading, whereas credit bottlenecks, weak branding or fragmented governance impede progress. By aligning CAP eco-schemes with digital innovation and

inclusive finance, Poland can convert its moderate production growth into a durable competitive advantage, positioning itself as an EU benchmark for sustainable apiculture. Future research should adopt hybrid analytical frames and real-time sensor datasets to capture dynamic shocks – climate volatility, market swings, regulatory shifts – and safeguard both pollinator ecosystems and rural livelihoods.

Authors' Contribution

The authors' individual contribution is as follows: Igor Olech: conceptualisation, research, analysis. Artur Olech: research, analysis.

Conflict of Interest

The authors declare no conflict of interest.

References

Al-Ghamdi, A. A., Adgaba, N., Tadesse, Y., Getachew, A., & Al-Maktary, A. A. (2017). Comparative Study on the Dynamics and Performances of Apis Mellifera Jemenitica and Imported Hybrid Honeybee Colonies in Southwestern Saudi Arabia. *Saudi Journal of Biological Sciences*, *24*(5), 1086–1093. https://doi.org/10.1016/j.sjbs.2017.01.008

Athari, S. A., Kırıkkaleli, D., Yousaf, I., & Ali, S. (2022). Time and Frequency Co-movement between Economic Policy Uncertainty and Inflation: Evidence from Japan. *Journal of Public Affairs*, *22*(S1), e2779. https://doi.org/10.1002/pa.2779

Bajan, B., Łukasiewicz, J., & Smutka, L. (2021). Similarity and Competition of Polish Agri-food Export with the Largest Agricultural Producers in the EU: Analysis of EU, US, and China Market. *AGRIS on-line Papers in Economics and Informatics*, *13*(1), 29–47. https://doi.org/10.7160/aol.2021.130103

Bayissa, M., Lauwers, L., Mitiku, F., de Graaf, D. C., & Verbeke, W. (2024). System Mapping of the Production and Value Chain to Explore Beekeeping Potential in Southwest Ethiopia. *Insects*, *15*(2), 106. https://doi.org/10.3390/insects15020106

Bieńkowska, M., Łoś, A., & Węgrzynowicz, P. (2020). Honey Bee Queen Replacement: An Analysis of Changes in the Preferences of Polish Beekeepers through Decades. *Insects*, *11*(8), 544. https://doi.org/10.3390/insects11080544

Boratyńska, K. (2025). Risk Challenges and Their Impact on the Sustainable Food Security System: Lessons Learned from the COVID-19 Pandemic. *Sustainability*, *17*(1), 226. https://doi.org/10.3390/su17010226

Calle, J. L. P., Ferreiro-González, M., Aliaño-González, M. J., Espada-Bellido, E., Palma, M., & Barbero, G. F. (2021). Quality Control of Honey by Visible and Near Infrared Spectroscopy (Vis-NIRS) and Headspace-Ion Mobility Spectrometry (HS-IMS). In: *Proceedings of the 3rd International Electronic Conference on Environmental Research and Public Health* (pp. 11–25). MDPI. https://doi.org/10.3390/ecerph-3-09079

Çevrimli, M., & Sakarya, E. (2019). Economic Analysis of Beekeeping Enterprises in Aegean Region, Turkey. *Ankara Üniversitesi Veteriner Fakültesi Dergisi*, *66*(2), 109–115. https://doi.org/10.33988/auvfd.547464

Delgado, D. L., Pérez, M. E., Galindo-Cardona, A., Giray, T., & Restrepo, C. (2012). Forecasting the Influence of Climate Change on Agroecosystem Services: Potential Impacts on Honey Yields in a Small-island Developing State. *Psyche: A Journal of Entomology*, *2012*, 951215. https://doi.org/10.1155/2012/951215

Dicks, L. V., Abrahams, A., Atkinson, J., Biesmeijer, J., Bourn, N., Brown, C., Brown, M. J. F., Carvell, C., Connolly, C., Cresswell, J. E., Croft, P., Darvill, B., De Zylva, P., Effingham, P., Fountain, M., Goggin, A., Harding, D., Harding, T., Hartfield, C., ... Sutherland, W. J. (2012). Identifying Key Knowledge Needs for Evidence-based Conservation of Wild Insect Pollinators: A Collaborative Cross-sectoral Exercise. *Insect Conservation and Diversity*, *6*(3), 435–446. https://doi.org/10.1111/j.1752-4598.2012.00221.x

Dluhošová, S., Borkovcová, I., Kaniová, L., & Vorlová, L. (2018). Sulfonamide Residues: Honey Quality in the Czech Market. *Journal of Food Quality*, *2018*, 2939207. https://doi.org/10.1155/2018/2939207

European Commission. (2023). *Overview of the Annual Performance Report for Apiculture Sectoral Support under CAP Strategic Plans FY 2023*. Retrieved from: https://agriculture.ec.europa.eu/document/download/41cd969f-176f-4dcc-810c-9b617dc53580_en (accessed: 4.03.2025).

Fakhlaei, R., Selamat, J., Khatib, A., Razis, A., Sukor, R., Ahmad, S., & Babadi, A. (2020). The Toxic Impact of Honey Adulteration: A Review. *Foods*, *9*(11), 1538. https://doi.org/10.3390/foods9111538

Gajda, A., Antczak, M., Mitrowska, K., & Posyniak, A. (2018). Development, Validation and Application to Real Samples of a Liquid Chromatography with Tandem Mass Spectrometry Method for the Determination of Tetracyclines in Beeswax. *Journal of Separation Science*, *41*(20), 3821–3829. https://doi.org/10.1002/jssc.201800503

Gałczyńska, M., Gamrat, R., Bosiacki, M., Sotek, Z., Stasińska, M., & Ochmian, I. (2021). Micro and Macroelements in Honey and Atmospheric Pollution (NW and Central Poland). *Resources*, *10*(8), 86. https://doi.org/10.3390/resources10080086

Grecka, K., Kuś, P. M., Worobo, R. W., & Szweda, P. (2018). Study of the Anti-staphylococcal Potential of Honeys Produced in Northern Poland. *Molecules*, *23*(2), 260. https://doi.org/10.3390/molecules23020260

Halagarda, M., Groth, S., Popek, S., Rohn, S., & Pedan, V. (2020). Antioxidant Activity and Phenolic Profile of Organic and Conventional Honeys from Poland. *Antioxidants*, *9*(1), 44. https://doi.org/10.3390/antiox9010044

Hamzah, E. F. B., & Anggoro, Y. (2023). Revitalizing PT. Sindo Energy: Proposed Scenario Planning to Navigate Coal-regulatory Changes. *International Journal of Current Science Research and Review*, *6*(12). https://doi.org/10.47191/ijcsrr/v6-i12-55

Haryadi, T., Ulumuddin, D. I. I., Prabowo, D. P., & Ihwan, A. M. (2022). Adaptasi Digital Marketing berbasis Website untuk Produk UMKM Fatikha Sweet Honey. *Jurnal Informatika Upgris*, *8*(1), 52–58. https://doi.org/10.26877/jiu.v8i1.11524

Kagiali, E., Kokoli, M., Vardakas, P., Goras, G., Hatjina, F., & Patalano, S. (2023). Four-Year Overview of Winter Colony Losses in Greece: Citizen Science Evidence That Transitioning to Organic Beekeeping Practices Reduces Colony Losses. *Insects*, *14*(2), 193. https://doi.org/10.3390/insects14020193

Kazazić, M., & Mehić, E. (2024). Physicochemical Properties, Total Phenolic Content, and Antioxidant Activity Of Honey Samples from the Herzegovina Region. *Agroznanje*, *25*(1). https://doi.org/10.7251/agren2401033k

Kek, S. P., Chin, N. L., Yusof, Y. A., Tan, S. W., & Chua, L. S. (2017). Classification of Entomological Origin of Honey Based on its Physicochemical and Antioxidant Properties. *International Journal of Food Properties*, *20*(sup3), S2723–S2738. https://doi.org/10.1080/10942912.2017.1359185

Kędzierska-Matysek, M., Teter, A., Skałecki, P., Topyła, B., Domaradzki, P., Poleszak, E., & Florek, M. (2022). Residues of Pesticides and Heavy Metals in Polish Varietal Honey. *Foods*, *11*(15), 2362. https://doi.org/10.3390/foods11152362

Kocot, J., Kiełczykowska, M., Luchowska-Kocot, D., Kurzepa, J., & Musik, I. (2018). Antioxidant Potential of Propolis, Bee Pollen, and Royal Jelly: Possible Medical Applications. *Oxidative Medicine and Cellular Longevity*, *2018*, 7074209. https://doi.org/10.1155/2018/7074209

Kowalczuk, I., Jeżewska-Zychowicz, M., & Trafiałek, J. (2017). Conditions of Honey Consumption in Selected Regions of Poland. *Acta Scientiarum Polonorum Technologia Alimentaria*, *16*(1), 101–112. https://doi.org/10.17306/J.AFS.2017.0446

Kowalczuk, I., Stangierska, D., Widera, K., Fornal-Pieniak, B., & Latocha, P. (2023). Determinants of Honey Consumption with Special Reference to the Influence of Nutritional Knowledge and Health Status on Consumption Habits. *Applied Sciences*, *13*(2), 979. https://doi.org/10.3390/app13020979

Kumsa, T., & Takele, D. (2014). Assessment of the Effect of Seasonal Honeybee Management on Honey Production of Ethiopian Honeybee (Apis Mellifera) in Modern Beekeeping in Jimma Zone. *Greener Journal of Plant Breeding and Crop Science*, *2*(3), 067–075.

Kurdin, I., & Kurdina, A. (2025). Internet of Things Smart Beehive Network: Homogeneous Data, Modeling, and Forecasting the Honey Robbing Phenomenon. *Inventions*, *10*(2), 23. https://doi.org/10.3390/inventions10020023

Ligor, M., Kowalkowski, T., & Buszewski, B. (2022). Comparative Study of Potentially Toxic and Essential Elements in Honey by Geographic Origin. *Molecules*, *27*(17), 5474. https://doi.org/10.3390/molecules27175474

Maciejczak, M., Olech, I., & Kalinka, K. (2023). Functioning of Selected Beekeeping Farms in Poland during COVID-19 Pandemic. *Acta Scientiarum Polonorum Oeconomia*, *22*(1), 47–54. https://doi.org/10.22630/ASPE.2023.22.1.4

Majewski, J. (2014). Wartość zapylania sadów jabłoniowych w Polsce – próba szacunku metodą kosztów zastąpienia. *Roczniki Naukowe Ekonomii Rolnictwa i Rozwoju Obszarów Wiejskich*, *101*(3), 126–132. https://doi.org/10.22630/RNR.2014.101.3.39

Malagnini, V., Cappellari, A., Marini, L., Zanotelli, L., Zorer, R., Angeli, G., Ioriatti, C., & Fontana, P. (2022). Seasonality and Landscape Composition Drive the Diversity of Pollen Collected by Managed Honey Bees. *Frontiers in Sustainable Food Systems*, *6*, 865368. https://doi.org/10.3389/fsufs.2022.865368

Mancuso, T., Croce, L., & Vercelli, M. (2020). Total Brood Removal and Other Biotechniques for Sustainable Control of Varroa Mites in Honey Bee Colonies: Economic Impact in Beekeeping Farm Case Studies in Northwestern Italy. *Sustainability*, *12*(6), 2302. https://doi.org/10.3390/su12062302

Messeri, A., Arcidiaco, L., Bianca, E., Tiako, D., Orlandini, S., Messeri, G., & Mancini, M. (2024). Effects of Air Temperatures on Acacia and Chestnut Honey Yields: Case Study in Italy. *Italian Journal of Agrometeorology*, *1*, 49–58. https://doi.org/10.36253/ijam-2296

Ministry of Agriculture and Rural Development. (2024). *CAP Strategic Plan 2023–2027*. Retrieved from: https://www.gov.pl/attachment/71624a74-a08f-4f07-b014-a06fa3ba0e6c (accessed: 4.03.2025).

Naila, A., Julika, W. N., Flint, S., Sulaiman, A. Z., Mohamed, A., & Ajit, A. (2021). Analysis of Adulterants in International Honey Available in The Maldives. *ACS Food Science & Technology*, *1*(8), 1373–1380. https://doi.org/10.1021/acsfoodscitech.0c00144

Narang, A., Kumar, D., & Gupta, G. (2022). Political, Economical, Social, Technological and SWOT Analysis of Beekeeping as a Successful Enterprise in India: An Overview. *Journal of Applied and Natural Science*, *14*, 194–202. https://doi.org/10.31018/jans.v14i1.3312

Nurleli, Sri Kuntorini, R., Fauzan, A., Halimatusadiah, E., Oktaroza, M. L., Suhandoyo, R., Utama, G., & Sri Wahyuni, A. (2023). Application of Information Technology (E-commerce) in Increasing MSME Income in Tourism Villages. *KnE Social Sciences*, *8*(18), 1420–1427. https://doi.org/10.18502/kss.v8i18.14346

Olech, I., & Olech, A. (2024). Dynamika cen miodu w Polsce w latach 2003–2022. In: *X Ogólnopolska Konferencja Pszczelarstwo a zrównoważony rozwój rolnictwa: Ogólnopolski konkurs Pszczelarz Roku, X Edycja* (pp. 61–81). Instytut Ekonomiki Rolnictwa i Gospodarki Żywnościowej, Państwowy Instytut Badawczy.

Park, B., & Nieh, J. C. (2017). Seasonal Trends in Honey Bee Pollen Foraging Revealed through DNA Barcoding of Bee-collected Pollen. *Insectes Sociaux*, *64*(3), 425–437. https://doi.org/10.1007/s00040-017-0565-8

Pasimeni, P. (2021). Poland in the European Union Single Market. *Economic and Regional Studies/Studia Ekonomiczne i Regionalne*, *14*(3), 265–278. https://doi.org/10.2478/ers-2021-0019

Pawlak, K., & Smutka, L. (2022). Does Poland's Agri-food Industry Gain Comparative Advantage in Trade with Non-EU Countries? Evidence from the Transatlantic Market. *PLoS ONE*, *17*(9), e0274692. https://doi.org/10.1371/journal.pone.0274692

Pawłowska-Tyszko, J., Jarka, S., & Olech, I. (2024). Food Self-sufficiency in the Honey Market in Poland. *Sustainability*, *16*(21), 9373. https://doi.org/10.3390/su16219373

Pellissery, S., Raja, K., & James, A. (2012). Market Integration for Inclusive Growth: Insights from Sociology of the Market. *Review of Market Integration*, *4*(1), 45–69. https://doi.org/10.1177/097492921200400102

Piechowicz, B., Kuliga, A., Kobylarz, D., Koziorowska, A., Zaręba, L., Podbielska, M., Piechowicz, I., & Sadło, S. (2022). A Case Study on the Occurrence of Pyrimethanil, Cyprodinil and Cyflufenamid Residues in Soil and on Apple Leaves, Blossoms and Pollen, and Their Transfer by Worker Bees to the Hive. *Journal of Plant Protection Research*, *62*(2), 176–188. https://doi.org/10.24425/jppr.2022.141355

Pisulewski, A., & Marzec, J. (2022). The Impact of Subsidies on Persistent and Transient Technical Inefficiency: Evidence from Polish Dairy Farms. *Journal of Agricultural and Applied Economics*, *54*(4), 561–582. https://doi.org/10.1017/aae.2022.26

Puścion-Jakubik, A., Bielecka, J., Grabia, M., Markiewicz-Żukowska, R., Soroczyńska, J., Teper, D., & Socha, K. (2022). Comparative Analysis of Antioxidant Properties of Honey from Poland, Italy, and Spain Based on the Declarations of Producers and Their Results of Melissopalinological Analysis. *Nutrients*, *14*(13), 2694. https://doi.org/10.3390/nu14132694

Quinlan, G. M., Miller, D. A. W., & Grozinger, C. M. (2023). Examining Spatial and Temporal Drivers of Pollinator Nutritional Resources: Evidence from Five Decades of Honey Bee Colony Productivity Data. *Environmental Research Letters*, *18*(11), 114018. https://doi.org/10.1088/1748-9326/acff0c

ReportLinker. (2023a). *Forecast: Honey Production in Poland*. Retrieved from: https://www.reportlinker.com/dataset/3f6109174343ff7f8ddad95a25e8cf9d695465b3 (accessed: 18.02.2025).

ReportLinker. (2023b). *Forecast: Natural Honey Production in Poland*. Retrieved from: https://www.reportlinker.com/dataset/11b0513974e46d34ce7147d54a17d9b1323f5c6c (accessed: 18.02.2025).

Rodrigues, H., Leite, M., Oliveira, B., & Freitas, A. (2024). Antibiotics in Honey: A Comprehensive Review on Occurrence and Analytical Methodologies. *Open Research Europe*, *4*, 125. https://doi.org/10.12688/openreseurope.17664.2

Scripcă, L. A., & Amariei, S. (2021). Influence of Chemical Contaminants on the Physicochemical Properties of Unifloral and Multifloral Honey. *Foods*, *10*(5), 1039. https://doi.org/10.3390/foods10051039

Semkiw, P., & Skubida, P. (2021). Bee Bread Production – a New Source of Income for Beekeeping Farms? *Agriculture*, *11*(6), 468. https://doi.org/10.3390/agriculture11060468

Singh, I., & Singh, S. (2018). Honey Moisture Reduction and Its Quality. *Journal of Food Science and Technology*, *55*(10), 3861–3871. https://doi.org/10.1007/s13197-018-3341-5

Singh, V., Jatav, S., & Pasumarti, S. S. (2025). The Path towards Sustainable Hydrogen-based Economy: A Pestle Analysis of India. In: F. Özsungur, M. Chaychi Semsari, H. Küçük Bayraktar (Eds), *Geopolitical Landscapes of Renewable Energy and Urban*

Growth (pp. 185–212). IGI Global Scientific Publishing. https://doi.org/10.4018/979-8-3693-8814-3.ch006

Soares, S., Amaral, J. S., Oliveira, M. B. P. P., & Mafra, I. (2017). A Comprehensive Review on the Main Honey Authentication Issues: Production and Origin. *Comprehensive Reviews in Food Science and Food Safety*, *16*(5), 1072–1100. https://doi.org/10.1111/1541-4337.12278

Starowicz, M., Hanus, P., Lamparski, G., & Sawicki, T. (2021). Characterizing the Volatile and Sensory Profiles, and Sugar Content of Beeswax, Beebread, Bee Pollen, and Honey. *Molecules*, *26*(11), 3410. https://doi.org/10.3390/molecules26113410

Suhri, A. G. M. I., & Bahar, I. (2023). Water Content of Stingless Bee Honey Varies by Season. *Jurnal Biologi Tropis*, *23*(2), 16–22. https://doi.org/10.29303/jbt.v23i2.4651

Szczepaniak, I. (2018). Comparative Advantages in Polish Export to the European Union – Food Products vs Selected Groups of Non-food Products. *Oeconomia Copernicana*, *9*(2), 287–308. https://doi.org/10.24136/oc.2018.015

Taha, E. K. A., & Al-Kahtani, S. N. (2019). Comparison of the Activity and Productivity of Carniolan (*Apis mellifera carnica* Pollmann) and Yemeni (*Apis mellifera jemenitica* Ruttner) Honey Bee Subspecies under Environmental Conditions of the Al-Ahsa Oasis of Eastern Saudi Arabia. *Saudi Journal of Biological Sciences*, *26*(4), 681–687. https://doi.org/10.1016/j.sjbs.2017.10.009

Tarapatskyy, M., Sowa, P., Zaguła, G., Dżugan, M., & Puchalski, C. (2021). Botanical Origin Assessment of Polish Honeys Based on Physicochemical Properties and Bioactive Components. *Molecules*, *26*(16), 4801. https://doi.org/10.3390/molecules26164801

Tarekegn, A., Faji, M., Abebe, A., & Bezabeh, A. (2022). Production Performance, Defensive, Hygienic, Swarming, and Foraging Behavior of Apis Mellifera Scutellata Bee Race. *Research Square*. https://doi.org/10.21203/rs.3.rs-1743077/v1

Thomas, P. J. M., Sandwell, P., Williamson, S. J., & Harper, P. W. (2021). A PESTLE Analysis of Solar Home Systems in Refugee Camps in Rwanda. *Renewable and Sustainable Energy Reviews*, *143*, 110872. https://doi.org/10.1016/j.rser.2021.110872

Tkachenko, H., Kurhaluk, N., Lukash, O., Yakovenko, O., Opryshko, M., Maryniuk, M., Gyrenko, O., & Buyun, L. (2023). In Vitro Antibacterial Efficacy of Different Natural Linden Honeys against Some Gram-positive and Gram-negative Strains. *Agrobiodiversity for Improving Nutrition Health and Life Quality*, *7*(2). https://doi.org/10.15414/ainhlq.2023.0018

Tultabayeva, T., Zhumanova, U., Tultabayev, M., & Shaman, A. (2023). An Econometric Analysis of Price Elasticity and Demand Factors in the Global Honey and Honey-based Beverage Markets. *Economic Annals-XXI*, *202*(3–4), 40–51. https://doi.org/10.21003/ea.V202-04

Verbeke, W., Diallo, M. A., van Dooremalen, C., Schoonman, M., Williams, J. H., Van Espen, M., D'Haese, M., & de Graaf, D. C. (2024). European Beekeepers' Interest in Digital Monitoring Technology Adoption for Improved Beehive Management. *Computers and Electronics in Agriculture*, *227*, part 1, 109556. https://doi.org/10.1016/j.compag.2024.109556

Wróblewska, A., & Stawiarz, E. (2015). Botanical Characteristics of Polish Honeys from Natura 2000 Habitats. *Journal of Apicultural Science*, *59*(1), 39–49. https://doi.org/10.1515/jas-2015-0003

Zalengera, C., Blanchard, R. E., Eames, P. C., Juma, A. M., Chitawo, M. L., & Gondwe, K. T. (2014). Overview of the Malawi Energy Situation and a PESTLE Analysis for Sustainable Development of Renewable Energy. *Renewable and Sustainable Energy Reviews*, *38*, 335–347. https://doi.org/10.1016/j.rser.2014.05.050

Żuchowski, I., & Olszewski, T. (2023). The Honey Market in Poland in the Years 2016–2021. *Scientific Journal HE-SS in Ostroleka*, *3*(50), 67–76.