

# Opportunities for developing a business model of Mediterranean beekeeping

## Mogućnosti razvoja poslovnog modela mediteranskog pčelarstva

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### Abstract

The research aims to determine the conditions in the beekeeping sector of Mediterranean area at the case study of Dubrovnik-Neretva County, to identify areas with special environmental profile, to evaluate the honey produced in these areas and to analyze the possibility of linking beekeeping with tourism and related industries and services. According to a set of targets, several activities were conducted: analysis of the types of honey, technological processes and deviations from good beekeeping practices, determining the amount of investment, yields and income in honey production, analysis of the sales price, grade of marketability and sales channels of honey. The results show opportunities in production improvements by certain types of beekeepers, ways of beekeepers organizations and business associations and all that towards greater utilization of beekeeping capacity, as well as the increase of the commercial value of bee products and its integration with other economic activities.

**Keywords:** business model, economics, Mediterranean beekeeping

### Sažetak

Istraživanjem se željelo utvrditi stanje u sektoru pčelarstva mediteranskog područja, na slučaju Dubrovačko-neretvanske županije, identificirati područja s posebnim okolišnim profilom, valorizirati med proizveden na tim područjima te analizirati mogućnost povezivanja pčelarstva s turizmom i sličnim djelatnostima i uslugama. U skladu s postavljenim ciljevima provedeno je više aktivnosti: analiza vrsta meda, tehnološki postupci i odstupanja od dobre pčelarske prakse, utvrđivanje visine ulaganja, prinosa i dohotka u proizvodnji meda, analiza prodajne cijene, stupnja

tržnosti i kanala prodaje meda. Rezultati istraživanja dali su kvalitetnu podlogu za preporuku unaprjeđenja proizvodnje po pojedinim tipovima pčelara, načinima organizacije pčelarstva i poslovnog udruživanja proizvođača u pravcu većeg iskorištenja pčelarskih kapaciteta ovog područja, kao i veće komercijalne vrijednosti pčelinjih proizvoda, kako u okviru samog pčelarenja, tako i u njegovom povezivanju s drugim gospodarskim djelatnostima.

**Ključne riječi:** ekonomika, mediteransko pčelarstvo, poslovni model

## Introduction

Beekeeping has long tradition in Croatian Mediterranean area (Alaupović-Gjeldum et al., 2004). Nowadays, beekeeping faces a number of challenges, from winter colony losses (Svečnjak et al., 2009; van der Zee et al., 2014) to habitat loss and fragmentation, agrochemicals, pathogens, alien species, climate change and the interactions between them (Potts et al., 2010). In comparison to other Croatian regions (Kezić et al., 2008, 2009; Brščić et al., 2013), for Mediterranean area only limited data about beekeeping are available. Therefore, this research is focused on the physical and financial characteristics, as well as on socioeconomic conditions of Mediterranean beekeepers. The main objective of the research is to identify areas with significant production of honey in relation to characteristic environmental profile (e.g. the presence of citrus, exclusive production on the islands, the dominant presence of certain herbs and aromatic plants, etc.). Along with that, the possibilities of linking beekeeping with the tourism and related services are analyzed.

National Agricultural Policy and its objectives are defined by the Agriculture Act (NN 149/09), where the basic goals of agriculture are given, and important one is the preservation of natural resources by promoting sustainable, ecological agriculture and the preservation and advancement of rural areas and rural values. In the Mediterranean part of Croatia there are significant areas that are covered by the Nature Protection Act (NN 70/05, 139/08) and beekeeping is a significant contributor to the conservation of biodiversity. In agricultural production, demand for recognizable products (organic, traditional) is growing, consumed or purchased in the area where they are produced.

Importance of market value illustrates example of China that exports similar honey quantities as Argentina (leader in honey exporting) but earns almost 1/3 less money, while Germany exports only 1/4 of the amount of Argentina's honey but earns half the amount of money Argentina does (Cvitković et al., 2009).

## Materials and methods

Based on melissopalynological and physico-chemical analysis of honey (made in 2011), several production areas and types of honey have been defined, which deserve attention from the aspect of exploiting beekeeping resources in the Mediterranean and increasing of beekeeping income, based on product labeling of honey with a higher sales value.

Types of honey and major honey producing plants are described on the basis of data from the research project (Bubalo et al., 2009) "Palynological characteristics of nectar and honey of sage (*Salvia officinalis*)" and conducted evaluation of honey, collected directly from beekeepers on the meetings of the association.

Visiting the farms and interviewing the beekeeping producers, status and methods of beekeeping were established. Special attention is given to the share of hobby, additional or professional beekeepers. The frequency and efficiency of migrating and stationary beekeeping has been evaluated.

Data about produced quantities by types of honey, production cost and honey sales channels have been collected through the surveys of honey producers. For the analysis of the sales prices, the statistical reports and TISUP database (Market information system in agriculture, the Ministry of Agriculture, Fisheries and Rural Development) were used, as well as interviewing the beekeepers.

SWOT analysis in line with the research goals was applied according to both the examination of the attitudes and opinions of the beekeepers involved and analysis of the other data available like surveying the production capacity for honey and other bee products per types and forms of producer's business organization.

Climate data have been collected from Meteorological and hydrological service of Croatia (MHSC).

The business model presented in this paper will provide a quality baseline for recommendations for the improvement of production by certain types of beekeepers, ways of organizing both, the beekeeping practices and business associations of beekeeping producers, aiming greater efficiency of beekeeping capacity in this area, as well as the higher commercial value of Mediterranean bee products.

## Results and discussion

Dubrovnik-Neretva County is located in the south of Croatia and has all the characteristics of Mediterranean climate (Štefanić et al., 2004). Winters are mild with an average temperature of 9.6 °C, summers are hot with drought periods and average summer temperature is 24.5 °C. The greatest amount of rainfall has been recorded at the transition from autumn to winter (an average of 200 mm in December), average number of sunny days is 106-111 per year (windy 313), and winds per average frequency are from south (30%), north (up 29%), west (up 24%) and the east (to 15%).

Socio-economic characteristics of beekeepers were obtained from the survey of honey producers at three locations that reflected specificities of beekeeping population on Mediterranean area. The survey was conducted on 71 beekeepers, and the total capacity of those surveyed was 3,852 beehives, which is a sample of the total population of beekeepers in the County (Croatian Beekeepers Association has 221 registered beekeepers with about 7,600 production beehives; the Croatian Agricultural Agency has 125 beekeepers with about 9,200 beehives). The average number of colonies per surveyed beekeeper is 55, which is similar to Hungarian average according to Nyars (2003).

Only one third of surveyed honey producers operate as family farm in the VAT system, those are mainly producers who have more than 60 beehives. Grgić and Očić (2004) concluded that beekeeping business under VAT system is something that larger beekeepers should not avoid and is in accordance with EU guidelines. Most of beekeepers use the Langstroth beehives, what is in accordance with previous research of Svečnjak et al. (2008) that 70% of beekeepers in Mediterranean region use this type of beehives. Smaller beekeepers mainly keep beehives stationary, while larger beekeepers move (migrate) their beehives. This is one of the reasons why larger producers can achieve favorable economic conditions through the increase of yields of honey per hive up to 60 kg/hive (Kezić et al., 2007; Grgić et al., 2009).

According to the Table 1, slightly more than 26% of surveyed are beekeepers with less than 30 beehives, which represent the classic population of hobbyists. Around 42% of surveyed possesses 30-60 beehives, and they intend to grow the number of hives up to 80 in the near future, in order to stabilize production and sale of honey as very good additional activity and source of income. Around one quarter of the population intends to increase its capacity to over 100 beehives and focus on fully commercial production. Populations with 60-100 and over 100 beehives are represented by the 15% in the total sample, and they are extremely market oriented. The highest yield average per beehive is achieved in category of producers with 60-100 hives, which is probably caused by the number of beehives that are relatively easily for monitoring and managing by farmer-beekeeper. It is also easier to organize this number of beehives for migrating beekeeping, as the main factor of higher yields per beehive. Semkiw and Skubida (2010) showed at Polish example how different the yields are in small apiaries (15 kg/beehive) compared to the commercial ones (26 kg/beehive).

In the structural share of beekeepers with over 100 beehives - most frequent is multifloral honey (50-60%), whereas in equal proportions (20-25%) of sage and heather (*Erica spp.*) honeys are present. Other categories of beekeepers often sell only one type of honey or differentiate honey by the time of extracting, as spring and autumn. The most common producers of other bee products (mainly propolis) are large beekeepers with more than 100 beehives.

Table 1. The number of surveyed beekeepers, average capacity and production

Number of beehives	Number of beekeepers	Average beehives per beekeeper	Average honey production per hive (kg)
Less than 30	19	21	16.84
30 to 60	30	42	14.78
60 to 100	11	77	20.89
Over 100	11	120	18.33

Source: Own research.

All producers in the County area relatively easily sell up to 1,000 kg of honey at a good sales price practically "on their doorsteps". The most common selling price for honey of all categories of producers is 6.58 €/kg, while honey from heather or sage achieves selling price of almost 8 €/kg. Given that the average selling price is very good, all tested categories of beekeepers have good economic results (Table 2). As producers usually don't calculate their own work and the amortization of investment (as fixed costs) they consider profit more than showed income (2.68 to 3.58 € per kg of honey produced). Income from 938 to 2,019 € in the hobby and from 5.7 to 7.7 thousand € for commercial beekeepers, indicates a very good economic position of beekeeping.

Table 2. Overview of the beekeeping economics in groups of beekeepers and beehives

Number of beehives	In total (€)		Costs (€)				Profit, €
	Revenues	Material	Work services	Fixed	Own work	In total	
< 30	2,072	571	0	287	276	1,134	938
30 to 60	4,079	1,093	73	469	424	2,060	2,019
60 to 100	10,526	2,505	421	923	947	4,796	5,730
>100	14,474	2,808	1,013	1,623	1,303	6,746	7,728
€ per beehive							
< 30	99.74	27.48	0	13.81	13.30	54.59	45.15
30 to 60	97.27	26.07	1.75	11.18	10.12	49.11	48.15
60 to 100	137.45	32.71	5.5	12.05	12.37	62.63	74.82
>100	120.61	23.4	8.44	13.52	10.86	56.22	64.4
€ per kg of honey							
< 30	5.92	1.63	0	0.82	0.79	3.24	2.68
30 to 60	6.58	1.76	0.12	0.76	0.68	3.32	3.26
60 to 100	6.58	1.57	0.26	0.58	0.59	3	3.58
>100	6.58	1.28	0.46	0.74	0.59	3.07	3.51

Source: Own research.

Total investment per beehive is about 316 to 395 €, where the largest investments are in the category of small and the largest beekeepers (largest beekeepers invest in vehicles and trailers for migratory beekeeping).

The opinion of the most beekeepers is that organic production has not the best prospective neither today nor in the future demanding only higher investment and increased production cost. However, more than 10% of the respondents seriously intend to transform into organic beekeeping within the next five years. In the beekeeper's category of 60 and more beehives, 15–20% doesn't even think about transition to organic beekeeping practices. Besides the honey production (conventional and organic) beekeepers intend to deal with the production of royal jelly, bee venom and package bees. Beekeepers from west Herzegovina also showed low motivation for organic production because it requires more expenses without extra incomes (Kezić et al., 2006).

Around one third of the respondents would probably never join a beekeeping cooperative, 25% of them are already members, and the rest would probably join if they could recognize the business interest. All the beekeepers, regardless of their size, recognize the interest in cooperative business predominantly for the large purchases (like beehives and other equipment). Large beekeepers want to operate independently, as a craft or Ltd. Mid-size beekeepers are more oriented to partnership with bee-cooperatives or honey-purchasing companies, while the smaller beekeepers are oriented to family farms form of business. Previous researches show that beekeepers think about joining the cooperative only when the selling conditions are disturbed (Frick et al. 2006; Kezić et al. 2006).

SWOT analysis of beekeepers provided the focus on the areas where beekeepers are strong, as well as those with their greatest opportunities. The main strength was defined as the average size of apiary and location. Opportunities include diversification and production of other bee-products, promotion of bee-products, monitoring of bee-pastures and improvement of access, cooperatives and connection with tourism. This is in accordance with research of Roman et al. (2013) that showed how 63.9% of Polish consumers purchase the honey directly from beekeepers.

Small beekeepers can take their best chances by taking advantage of connecting their businesses with the chain of service providers for village and rural tourism, with additional possibility of transition to organic production. Integrated to one of the forms of vertical cooperation, they could more easily respond to the threats of their beekeeping. Large beekeepers have stronger power on the local market of bee products, especially honey, but they are sensitive to the seasonal changes in terms of climatic conditions and price of honey. Their advantage is that they have adopted a higher level of technology, they are relatively competitive in the given circumstances and for them beekeeping is already main activity - business. The opinion of the most beekeepers is that eco-production (organic) has not the best prospective neither today nor in the future demanding only higher investment and increased production cost. However, more than 10% of the respondents seriously intend to transform into organic beekeepers within the next five years. In the beekeeper's category of 60 and more beehives, 15–20% doesn't even think about transition to organic beekeeping practices and main reasons for that are: good current market price, relatively low cost of the conventional production and low level

of the incentives for organic beekeeping. The opinion of all categories of the beekeepers is that organic beekeeping is the most suitable for the small beekeepers and for the beginners.

During the three-year of honey competition, it was found that heather provides significant resources for the production of unifloral type of honey on Pelješac and Korčula. Heather's honey, thanks to its sensorial qualities, belongs to more aromatic types of honey. Sage's honey with its sensorial qualities belongs to the most valuable types of honey, produced in Mediterranean climate. However, the sage bee-pasture is extremely dependent on weather conditions (air temperature, relative humidity and air flow), which makes it unpredictable. Mandarin plantations are highly specific for the Mediterranean, but also in a much broader area, since Croatia is the northernmost area with major mandarin plantations in Europe. Honey of the strawberry tree is extremely bitter tasting, but because of its specific qualities (presence of glycosides) it is considered as therapeutically valuable. Besides the presence of glycosides, reasons for the high prices of this honey are limited resources and time period for the bee-pasture (October to December), when conditions are unfavorable for nectar secretion and honeybees' activity (lower temperatures and very frequent southern winds and rainfalls).

Analysis of the current organization of beekeepers through the beekeepers' association indicates relatively easy introduction of new technological measures, related to standardized beekeeping equipment in accordance with the modern technology standards. Beekeepers are interested to modernize their production according to newest technological trends using own capital investment of 6-13 € per beehive.

## Conclusion

Factors which have influence on the quantity and quality of nectar can be divided into internal and external. Internal (hereditary) factors are associated with anatomical properties of the plant species, while the external factors that affect the quality of nectar are weather and the soil. According to the average values of air temperature, the County fits into the conditions favorable for the secretion of nectar, however, from May to September dominates unfavorably dry season, followed by windy and rainy period until December. According to data from MHSC, the County has an average of 313 windy days per year, which significantly affects the efficiency of individual nectariferous bee-pasture, especially those more distant from the apiary. During the summer months, when the high temperature leads to stagnation of nectariferous plants development, bees enter a phase of summer mode (low profile activity). The summer period can adversely affect bee colonies if they are not provided with sufficient quantities of water and food. Some of beekeepers in this period moved the bees to the more suitable locations.

Socio-economic characteristics of beekeepers were obtained from the survey of honey producers that reflected specificities of beekeeping population on Mediterranean area. The average number of colonies per surveyed beekeeper is 55 and they use the Langstroth beehives.

Smaller beekeepers mainly keep beehives stationary, while larger beekeepers move (migrate) their beehives. This is one of the reasons why larger producers can achieve favorable economic conditions through the increase of yields of honey per hive.

The highest average yield per beehive is achieved in category of producers with 60-100 hives, which is probably caused by the number of beehives that are relatively easily for monitoring and managing by beekeeper. It is also easier to organize this number of beehives for migrating beekeeping, as the main factor of higher yields per beehive.

The main reasons for low interest in transition to organic beekeeping include: good current market price, relatively low cost of the conventional production and low level of the incentives for organic beekeeping. The opinion of all categories of the beekeepers is that organic beekeeping is the most suitable for the small beekeepers and for the beginners.

In the opinion of all respondents the success in cooperative business is less dependent on the individual initiative and individual integrity. It is more result of the government incentives, legal regulations of the bee-products trading and overall participation of the coop members in the cooperative management. Large beekeepers want to operate independently, registered as a craft or Ltd. Mid-size beekeepers are more oriented to partnership with bee-cooperatives or honey-purchasing companies, while the smaller beekeepers are oriented to Family farms form of business.

The bulk of the beekeeping investment refers to bee colonies and beehives, and then to the buildings and equipment. Since those are regularly in a long-term use that expenditure doesn't affect considerably the cost/price of honey.

Based on regional honey competition data, several production areas and types of honey have been defined, which deserve attention from the aspect of exploiting beekeeping resources in the Mediterranean area and increasing of beekeeping income, based on product labeling of honey with a higher sales value.

Production of honey and other bee products is strongly influenced by changing climatic conditions that directly affect the nectar flow. Additional challenge for the beekeepers is a limited access on public land and especially the access to the private land in case of migration at bee-pasture. Beekeepers complain about the import of the large honey quantities at very low (damping) prices. For all those reasons, it is necessary to provide education and guidance to the part of beekeepers for transition to some form of certified bee-production, which would contribute both to the education of consumers and promotion of beekeeping.

Since the average achieved selling price is very good; all evaluated categories of producers realize good economic results. Beekeepers with over 100 beehives their relative income increase manage trough the changes of beekeeping technology and increased price of honey. Commercial beekeepers with 60 to 100 beehives benefit from increased yield per beehive and business development by increasing number of beehives - with the intention of increasing the price by producing mono-floral types of honey.

Most frequent sales channel of registered producers is green market, followed by direct sales. To a lesser extent, larger producers, connect smaller part of its sales with tourism and related activities.

Monitoring and management of bee pasture is important organizational measure, which means placing beehives on beekeeping scales and their arrangement to the target pasture. The scale reads out the intensity of the nectar flow, and all coop/association members can remotely access to these data. Based on these, they can decide when and where to migrate. Applying the timely honey extraction they could optimally utilize available pasture and the apiary capacity. According to the expected average yields of 30 kg of honey per beehive of migratory beekeepers (60% of the population), total average would increase to nearly 20 kg of honey per beehive, compared to the current average of 17.4 kg/beehive or the EU-15 average of 15 kg/beehive.

There is possibility in the Mediterranean area for development of beekeeping through the production of high-quality genetic material, especially on the islands, where it is secured the area isolation needed for quality selection of queen bees adapted to local pastures, climatic and technological conditions.

Organizational and economic measures that could improve individual and total beekeeping in the Mediterranean are related to the establishment of beekeeping cooperatives/associations, common marketing policy and recognizable packaging design.

Existing road network doesn't provide access for the beekeepers to the most of the available bee pasture, whether due to an absence of the suitable positions for beekeepers or due to impossible access to the best pasture – which is necessary to improve with the assistance of the local authorities.

It is necessary to encourage promotion of honey and other bee products in tourism. Some of the ways are: demo apiary (adaptation of the selected apiaries for tourist and educational purposes), sales of Mediterranean typical types of honey in the recognizable packaging, founding of stores and tasting rooms (Honey boutique) with local honey products and transition from conventional to organic beekeeping practices which would ensure the organic honey as a complementary product for the growing touristic market.

## References

- Alaupović-Gjeldum, D., Matašin, Ž., Domaćinović, V. (2004) Pčela, čovjek, med i vosak u tradicijskoj kulturi Dalmacije. Split: Etnografski muzej Split.
- Brščić, K., Poljuha, D., Šiklič, J. (2013) Beekeepers perceptions about the importance of honey exhibitions and protection of geographical origin of honey – A case of Istria (Croatia). *Journal of Central European Agriculture*, 14 (4), 1473–1487. DOI: <http://dx.doi.org/10.5513/JCEA01/14.4.1378>.
- Bubalo, D., Peternel, R., Hegić, G., Svečnjak, L., Kezić, J. (2009) Melissopalynological characteristics of Croatian sage (*Salvia officinalis* L.) honey. In: International Federation of Beekeepers' Associations, 41st Apimondia congress, Montpellier, 15-20 September 2009.

- Cvitković, D., Grgić, Z., Matašin, Ž., Pavlak, M., Filipi, J., Tlak Gajger, I. (2009) Economic aspects of beekeeping production in Croatia. *Veterinarian archive*, 79, 4, 397-408.
- Frick, M., Grgić, Z., Franić, R., Štefanić, I., Kezić, N. (2006) Cooperative business potential for beekeepers in Croatia. *Journal of Apicultural Research*, 45, 4, 223-229.
- Grgić, Z., Očić, V. (2004) Pčelarska proizvodnja obiteljskih gospodarstava i PDV. In: Kezić, N., Dražić, M. M., 50. Obljetnica Hrvatskog pčelarskog saveza i 100. Obljetnica rođenja Akademika Ive Tomaseca utemeljitelja Hrvatskog pčelarskog saveza, Zagreb, Croatia, October 16-17 2004, Zagreb, Croatia: Hrvatski pčelarski savez. Available at: <https://www.bib.irb.hr/177685>.
- Grgić, Z., Očić, V., Petrović, I., Bubalo, D., Šakić Bobić, B. (2009) Ekonomska ocjena ulaganja u promijenjenu tehnologiju pčelarenja u obiteljskom gospodarstvu. *Stočarstvo: časopis za unapređenje stočarstva*, 63, 4, 287-296.
- Kezić, J., Ivanković, M., Svečnjak, L., Bubalo, D., Grgić, Z. (2006) Income of conventional and organic beekeeping in west Herzegovina. In: The 1st International conference on agriculture and rural development. Topusko, Croatia, November 23-25 2006.
- Kezić, J., Grgić, Z., Očić, V., Šakić Bobić, B. (2007) Socioekonomska obilježja pčelarenja i poslovno udruživanje pčelara. In: Proceedings from 42nd Croatian and 2nd International symposium on agriculture, Opatija, Croatia, February 13-16 2007.
- Kezić, J., Šakić Bobić, B., Svečnjak, L., Dražić, M. M., Grgić, Z., Kezić, N. (2008) Economic evaluation of beekeeping in Karlovačka county. *Journal of central European agriculture*, 9, 3, 615-620.
- Kezić, J., Grgić, Z., Šakić Bobić, B., Dražić, M. (2009) Ekonomska obilježja i konkurentnost različitih tipova pčelara u kontinentalnoj Hrvatskoj. In: 44th Croatian and 4th International symposium on agriculture, Opatija, Croatia, February 16-20 2009.
- Nyars, L. (2003) Situation and perspective of the Hungarian beekeeping. *Journal of Apicultural Science*, 47, 1, 59-66.
- Potts, S. G., Biesmeijer, J. C., Kremen, C., Neumann, P., Schweiger, O., Kunin, W. E. (2010) Global pollinator declines: trends, impacts and drivers. *Trends in ecology & evolution*, 25 (6), 345-353.
- Roman, A., Popiela-Pleban, E., Kozak, M. (2013) Factors influencing consumer behavior relating to the purchasing of honey. *Journal of Apicultural Science*, 57, 2, 159-172.
- Semkiw, P., Skubida, P. (2010) Evaluation of the economic aspects of Polish beekeeping. *Journal of Apicultural Science*, 54, 2, 5-15.
- Svečnjak, L., Hegić, G., Kezić, J., Turšić, M., Dražić, M. M., Bubalo, D., Kezić, N. (2008) The state of beekeeping in Croatia. *Journal of Central European Agriculture*, 9, 3, 475-482.

- Svečnjak, L., Dražić, M. M., Bubalo, D., Filipi, J., Kezić, N., Hegić, G. (2009) Prospects of Croatian beekeeping with regard to current situation and achievements. Abstracts of the COLOSS Work Shop New Molecular Tools, Bern, Swiss Bee Research Centre, 26-26.
- Štefanić, I., Štefanić, E., Puškadija, Z., Kezić, N., Grgić, Z. (2004) Beekeeping in the Republic of Croatia. *Bee world*, 85, 1, 19-21.
- Van der Zee, R., Brodschneider, R., Brusbardis, V., Charrière, J.D., Chlebo, R., Coffey, M. F., Dahle, B., Drazic, M M., Kauko, L., Kretavicius, J., Kristiansen, P., Mutinelli, F., Otten, C., Peterson, M., Raudmets, A., Santrac, V., Seppälä, A., Soroker, V., Topolska, G., Vejsnæs, F., Gray, A. (2014) Results of international standardised beekeeper surveys of colony losses for winter 2012-2013: analysis of winter loss rates and mixed effects modelling of risk factors for winter loss. *Journal of apicultural research*, 53 (1), 19-34.