sustainability

MDPI

Review

Urban Honey: A Review of Its Physical, Chemical, and Biological Parameters That Connect It to the Environment

David Quiralte [1], Inmaculada Zarzo [1,2], Maria-Angeles Fernandez-Zamudio [3,*], Héctor Barco [4] and Jose M. Soriano [1,5]

[1] Food & Health Lab, Institute of Materials Science, University of Valencia, 46980 Valencia, Spain
[2] University Clinic of Nutrition, Physical Activity and Physiotherapy, Lluís Alcanyís Foundation-University of Valencia, 46020 Valencia, Spain
[3] Centro para el Desarrollo de la Agricultura Sostenible, Instituto Valenciano de Investigaciones Agrarias, 46113 Valencia, Spain
[4] Enraíza Derechos, 20012 San Sebastián, Spain
[5] Joint Research Unit on Endocrinology, Nutrition and Clinical Dietetics, Health Research Institute, La Fe-University of Valencia, 46026 Valencia, Spain
* Correspondence: fernandez_marzam@gva.es

Abstract: Humans mainly use the land for agriculture and housing, resulting in the loss of natural habitat and a decrease in the number of species, including wild bees. The reduction of wild bees generates several negative consequences for the agricultural and ecosystem contexts, although sometimes the farming reduces the probability of abandonment of the land. In parallel, urban beekeeping has emerged and consolidated as one of the current trends, while the consumption of honey from urban environments is also growing. Current scientific literature establishes different physical, chemical, and biological parameters which evaluate the quality of honey products and its environment. The review carried out here collects the various compounds contained in this source-dependent food matrix from anthropogenic activities in the sampling area. Using gas and liquid chromatography and spectrometry, the main physicochemical parameters have been detected, 27 chemical elements, of which 6 are heavy elements, 16 polycyclic aromatic hydrocarbons (PAHs), polychlorinated biphenyls (PCBs), and pesticides (organochlorine pesticides and neonicotinoids). Additionally, their total phenolic and microbiological content has been typified. This analysis can help to frame the main characteristics to evaluate this universal product, whose consumption began with the first settlers of the world, and its properties have been evolving as well as the characteristics of the production systems.

Keywords: anthropized systems; urban environment; physical-chemical characterization; heavy elements; polycyclic aromatic hydrocarbons; polychlorinated biphenyls; pesticides; microbiological content

Citation: Quiralte, D.; Zarzo, I.; Fernandez-Zamudio, M.-A.; Barco, H.; Soriano, J.M. Urban Honey: A Review of Its Physical, Chemical, and Biological Parameters That Connect It to the Environment. *Sustainability* **2023**, *15*, 2764. https://doi.org/10.3390/su15032764

Academic Editor: Massimo Lucarini

Received: 9 December 2022
Revised: 28 January 2023
Accepted: 31 January 2023
Published: 3 February 2023

1. Introduction

The sustainability of food system primarily depends on the production systems and their link with human lifestyles. This is the case of honey, a universal product culturally rooted in world gastronomy which has evolved from being a food system obtained in natural circumstances, even in wildlife conditions, to being produced in an anthropized environment such as large cities, which makes it a grand adaptation challenge. In fact, in recent years, a sustainable activity based in urban beekeeping has grown in some large cities and states, as New York [1], London [2], Berlin [3] and Queensland (Australia) [4] are creating new green spaces. If honeybees are integrated into urban environments, it will help with the diffusion of biodiversity, which in turn will improve human living conditions [5] and enhance ecological revitalization, education, and community cohesion and cooperation [6]. Furthermore, urban planning and local site design can contribute to the success of urban agriculture while also benefiting biodiversity through the conservation of pollinators in urban environments [7]. It is achieved by considering social attitudes towards pollinators and, with green spaces scattered around the city, acting as friendly habitats for both bees and humans [8]. Urban green areas are an attractive source of food for bees whose foraging activity is useful [9] and are favorable for beekeeping [10] helping with the vision of a sustainable city with the coexistence of many different activities. Urban beekeeping has been implemented on top of large buildings, terraces, suburban gardens and farms [9]. In the United Kingdom, it has been tested to place barriers around apiaries to reduce bee stings [11]. The popularity of honey consumption in local markets and supermarkets has led to urban beekeeping becoming an attractive practice and, at the same time, has helped to combat the decline of the bee population [12]. Products from bees, such as honey or pollen, are being used as bioindicators to analyze environmental contamination and pollution in cities and their different areas [13,14], indicating the presence of heavy elements [15], polluting parameters [16,17] or pesticides [18] due to anthropogenic activities present in the sampling areas [14,17]. Thus, the review of the most relevant studies could provide guidance about the link of urban honey with its environmental setting, which looks set to become increasingly anthropized. The aim of this review is to report on the physical-chemical characterization, chemical elements, heavy elements, polycyclic aromatic hydrocarbons (PAHs), polychlorinated biphenyls (PCBs), pesticides, microbiological contents and total phenolic in urban honey.

2. Review Method

The procedure called 'Preferred Reporting Items for Systematic Reviews and Meta-Analyses' (PRISMA) [19] (Figure 1) was applied and the search was restricted until 20 October 2022, using two databases, PubMed and Ovid MEDLINE.

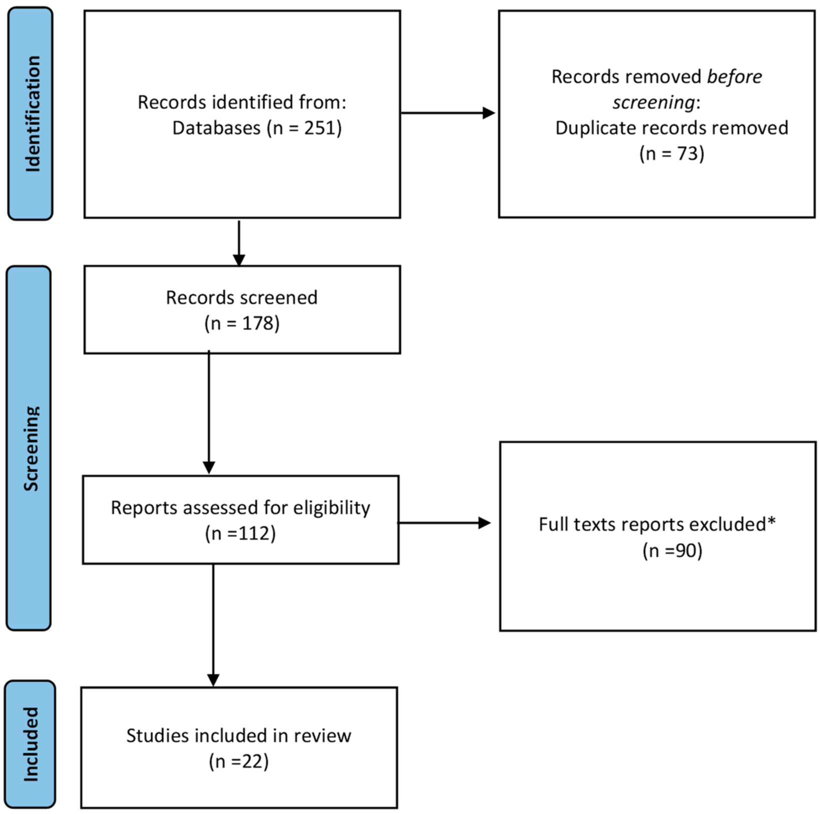

Figure 1. PRISMA (Preferred Reporting Items for Systematic Reviews and Meta-Analyses) flow diagram for studies retrieved through the searching and selection process. * The reasons for the exclusion of articles were reflected in this section.

The Boolean strings chosen were: 'urban honey' OR 'urban apiary' AND pH OR 'free acidity' OR lactone OR 'total acidity' OR HMF OR 'color intensity' OR color OR water OR 'water insoluble content' OR sucrose OR 'reducing sugars' OR moisture OR ash OR 'electrical conductivity" OR 'diastatic activity' OR 'chemical elements' OR silver (Ag) OR aluminum (Al) OR arsenic (As) OR boron (B) OR barium (Ba) OR calcium (Ca) OR cadmium (Cd) OR cobalt (Co) OR chromium (Cr) OR copper (Cu) OR iron (Fe) OR mercury (Hg) OR potassium (K) OR magnesium (Mg) OR manganese (Mn) OR molybdenum (Mo) OR sodium (Na) OR nickel (Ni) OR phosphorus (P) OR lead (Pb) OR sulphur (S) OR antimony (Sb) OR selenium (Se) strontium (Sn) OR vanadium (V) OR zinc (Zn) OR PAHs OR naphthalene (Np) OR acenaphthylene (Acy) OR acenaphthene (Ace) OR fluorene (F) OR phenanthrene (Ph) OR anthracene (An) OR fluoranthene (Fl) OR pyrene (Py) OR benzo[α]anthracene (B[α]An) OR benzo[β]fluoranthene (B[β]Fl) OR chrysene (Chry) OR benzo[κ]fluoranthene (B[κ]Fl) OR benzo[α]pyrene (B[α]Py) OR benzo[ghy]perylene (B[ghy]P) OR dibenzo[α,h]anthracene (dB[αh]An) OR indeno [1,2,3-cd]pyrene (I [123-cd]Py) OR microorganisms OR *Clostridium* OR *Bacillus* OR *Salmonella* OR fungi OR yeast OR 'phenolic activity' OR 'antioxidant capacity'.

As exclusion criteria, the reasons were report status as conference abstracts, review articles, case reports, letters, editorials, unpublished data, articles without full texts, articles with analysis in bee pollen, honeycomb or nectar or honey of rural apiary/urban landscapes and articles not available in English.

3. Urban Honey Characterization and Its Environment Link

3.1. Physical-Chemical Characterization

Table 1 shows data on physical-chemical parameters of urban honey in several studies.

Table 1. Mean ± standard deviation (SD)/range of studied physical-chemical parameters in urban honey.

Physical-Chemical Parameters	Country (Number of Samples) [Reference]			
	Italy (n = 6) [20]	Poland (n = 30) [21]	Serbia (n = 13) [22]	Ireland (n = 10) [23]
pH	3.63 ± 0.08 [a] 4.16 ± 0.07 [b]	4.08 ± 0.30	nd	3.53–4.51
Free acidity (mEq/kg)	32.26 ± 0.44 [a] 26.42 ± 2.15 [b]	nd	From 9.31 ± 0.58 to 43.7 ± 2.7	nd
Lactone (mEq/kg)	9.99 ± 1.11 [a] 12.28 ± 1.60 [b]	nd	nd	nd
Total acidity (mEq/kg)	42.25 ± 1.53 [a] 38.70 ± 1.77 [b]	nd	nd	nd
HMF (mg/kg)	26.71 ± 1.69 [a] 26.68 ± 2.71 [b]	nd	From 0.19 ± 0.03 to 17.86 ± 2.86	nd
Color intensity (mAU)	161.45 ± 7.61 [a] 174.71 ± 8.01 [b]	nd	nd	nd
Color (Pfund mm)	nd	nd	nd	71.42–158.14
Water (%m/m)	15.53 ± 0.67 [a] 14.83 ± 0.92 [b]	nd	nd	nd
Water-insoluble content (%)	nd	nd	From 0.002 ± 0.0004 to 0.04 ± 0.01	nd
Sucrose (%m/m)	2.36 ± 0.25 [a] 1.97 ± 0.41 [b]	nd	From 0.80 ± 0.06 to 4.56 ± 0.34	nd
Reducing sugars (%)	nd	nd	From 54.59 ± 1.25 to 77.40 ± 1.55	nd
Sugar (% Brix)	nd	nd	nd	65.42–85.00
Moisture content (%)	nd	15.42 ± 1.02	From 14.80 ± 0.50 to 19.22 ± 0.65	12.90–20.90
Ash (%)	nd	nd	From 0.07 ± 0.02 to 1.71 ± 0.48	nd
Electrical conductivity (ms/cm)	nd	0.55 ± 0.04	From 0.20 ± 0.01 to 1.33 ± 0.07	125.60–617.67
Diastase activity (Schade units)	nd	nd	From 29.24 ± 2.98 to 57.58 ± 5.87	nd

nd: not determined. [a] Sample harvested in July 2018. [b] Sample harvested in July 2019.

The study by Preti and Tarola [20] in Italy reflected two harvest years, including 2019 as a bad year for honey production in this Italian area due to the death of bee colonies, high temperatures and increased high-production losses, in contrast with the previous year, where rains and light temperatures favored flowering and lead to a good yield of polyfloral honey. All the quality values and their composition meet the EC criteria registered in the Codex Alimentarius Commission Standards [24] showing that the products have a good level of quality that is suitable for human consumption. On the contrary, the range of the study by Matović et al. [22] obtained 1.33 mS/cm, exceeding the legislated limit (no more than 0.8 mS/cm).

3.2. Macro, Trace and Heavy Elements

Table 2 shows the chemical elements reported in the various studies on urban honey. Furthermore, two other studies of urban honey were carried out to analyze lead obtaining 0.067 ± 0.078, as mean ± standard deviation, and below the detection limit, as range, in the USA [25] and France [26], respectively.

Table 2. Mean ± standard deviation (SD)/range of studied macro, trace and heavy elements in urban honey.

Chemical Elements and Heavy Elements (mg/kg)	**Country (Number of Samples) [Reference]**			
	Australia (*n* = 60) [4]	**Poland (*n* = 18) [27]**	**Serbia (*n* = 23) [16]**	**Czechia (*n* = 10) [28]**
Macrometals				
Calcium (Ca)	85.2 ± 39.9	74.6	nd	nd
Potassium (K)	965 ± 651	1411	nd	nd
Magnesium (Mg)	28.7 ± 19.6	21.6	nd	nd
Sodium (Na)	99.7 ± 82.5	15.3	nd	nd
Phosphorus (P)	51.5 ± 67.1	96.9	nd	nd
Trace elements				
Boron (B)	4.7 ± 2.2	4.71	nd	nd
Barium (Ba)	0.3 ± 0.2	0.10	nd	nd
Copper (Cu)	0.2 ± 0.4	0.29	<0.015–1.781	nd
Iron (Fe)	3.1 ± 8.0	2.50	<0.012–10.054	nd
Nickel (Ni)	0.0331 ± 0.107	0.03	<0.010–0.538	nd
Sulphur (S)	nd	42.2	nd	nd
Selenium (Se)	0.0052 ± 0.002	nd	nd	nd
Strontium (Sr)	0.4 ± 0.3	0.14	nd	nd
Vanadium (V)	0.0052 ± 0.001	nd	nd	nd
Zinc (Zn)	6.0 ± 16.6	3.47	<0.002–4.346	nd
Heavy elements				
Silver (Ag)	0.005 ± 0	nd	nd	nd
Aluminium (Al)	1.2 ± 1.5	nd	nd	nd
Arsenic (As)	0.0026 ± 0.001	<LOD	<0.001–0.009	<0.001–0.00435
Cadmium (Cd)	0.0031 ± 0.004	<LOD	<0.002–0.009	0.00095–0.03235
Chromium (Cr)	0.0077 ± 0.007	0.03	<0.005–0.833	nd
Cobalt (Co)	0.0167 ± 0.044	0.03	nd	nd
Mercury (Hg)	0.0025 ± 0	nd	<0.002–0.257	0.00324–0.01131
Manganese (Mn)	3.8 ± 4.1	0.45	0.079–2.428	nd
Molybdenum (Mo)	0.0115 ± 0.029	nd	nd	nd
Lead (Pb)	0.0286 ± 0.074	0.07	<0.003–0.107	0.0228–0.17785
Antimony (Sb)	0.0051 ± 0.001	nd	nd	nd
Tin (Sn)	0.0331 ± 0.049	nd	nd	nd

nd: not determined; LOD: limit of detection.

Acceptable and relatively even values are found in As, B, Ba, Cd, Co, K, Mg, Ni, P, Sr and Zn. The Ca values are relatively high at 93.22 mg/kg [29] and 74.60 mg/kg [27]. In the study carried out by Jovetić et al. [16] iron reached 10,054 mg/kg in some analyzed samples. The highest Cr content is 0.833 mg/kg, also in the same study. Manganese has a high value (2385 mg/kg [29]) which almost coincides with the highest value of Jovetić et al. [16] (2.428 mg/kg) and both much higher than the 0.45 mg/kg in the study by Gałczyńska et al. [27]. Sodium obtains a maximum value of 132.9 mg/kg [29].

Hungerford et al. [29] concluded that the average concentration of the elements Zn, Fe and Mg obtained in rural honey have higher values compared to those obtained in urban honey and detected the amounts of elements: Zn (10.90 mg/kg), Fe (4.01 mg/kg) and Mn (4.48 mg/kg) in rural environments, compared to those obtained in the urban area: Zn (4.90 mg/kg), Fe (1.576 mg/kg) and Mn (2.385 mg/kg).

Regarding heavy elements, Borsuk et al. [30] and Conti et al. [31] reported that the use of honey as a reference to measure the contamination in the environment by these chemical compounds is difficult because it requires the development of conversion factors to calculate the concentration and purification of metals in the nectar. Pollen presents element contents and values closer to those found by flowers and not purified by bees (such as honey).

The heavy elements detected in the studies collected and included in Table 2 are Cd, Cr, Cu, Hg, Pb and Zn. The amounts of these chemical elements and these heavy elements show that contamination depends on the environment where the bees live [32] and also on the origin of anthropogenic activities [14]. They have been detected in urban bees and their derived products [17,33]. Most heavy elements do not have legislation where their content is limited when concentrations are found in honey. Knowing that when their concentrations are higher than the maximum permitted limits, they become toxic and are risk elements [34].

From the Serbian study by Jovetić et al. [16], three heavy elements stand out above all: Cr, Cu and Hg. Cr reaches values of 0.833 mg/kg, and copper is found in their urban honey samples (n = 23) and ranges between <0.015–1.781 mg/kg. High Hg levels between <0.002–0.257 mg/kg in the study by Jovetić et al. [16] indicated clear evidence compared to other studies. Mercury exceeded in 3 samples (n = 3/23) the limit established which is 0.01 mg/kg for honey and other beekeeping products in EU Regulation 2018/73 [35].

Zn has been detected at very similar levels in this type of honey with maximum concentration values between 3.47 and 4.90 mg/kg. Cd registers low concentrations, with 0.03235 mg/kg being the maximum value in the study by Batelková et al. [28] in the Czech Republic.

For lead (Pb), there are several samples in Sheldon et al. [25] and Bilandžić et al. [36] that exceed this legal limit, for which the health of the consumer would be compromised. Honey from urban environments has trace element concentrations and Pb isotopic compositions that reflect proximity to anthropogenic activities such as shipping ports and heavy traffic being greater in comparison with suburban and rural environments [14]. In general, almost all the Pb values from urban honey were acceptable and suitable for human consumption according to EU Regulation 2021/1317 [37]. Lambert et al. [26] obtained the lowest values with 0.036 mg/kg of average concentration. The delimitation of 0.1 mg/kg of fresh weight of Pb in honey established in EU Regulation 2021/1317 [37] is exceeded in two studies, showing that, if they surpass this legal limit, the health of the consumer would be engaged. Sheldon et al. [25] and Bilandžić et al. [36] report a mean lead content of 2.073 mg/kg and 0.229 $\pm$ 0.334 mg/kg, respectively. Bilandzic et al. [36] attribute this increase in Pb content to growing urbanization and the risk of locating hives near highway and railway areas, while the contamination produced in the cities of Kentucky is reflected in the type of samples analyzed, putting the health of consumers at risk [25].

Finally, a study on polyfloral honey collected from industrialized areas (n = 24) reflected for Cd, Cu and Zn the following ranges, expressed in mg/kg: 0.05–3.81, 2.00–33.00, and 15.00–36.40, respectively. These high concentrations are due to the source of contamination that occurs in this area with industrial activity with non-ferrous metals for more than 60 years in the industrial platform of Copsa Mica, Romania. This study observed the importance of the location for the beekeepers and their influence on the honey produced [15].

3.3. Polycyclic Aromatic Hydrocarbons (PAHs) and Polychlorinated Biphenyls (PCBs)

Table 3 shows the values of PAHs in the urban honey samples. The values shown in the study by Dobrinas et al. [38] are the highest. In that study, PAHs without carcinogenic properties were detected in higher concentrations in urban areas than in rural ones. It could be due to atmospheric sources or to the soil through the nectar of plants. However, there is little evidence that PAHs are transferred from contaminated soil to them [39]. Despite the high PAH levels detected in honey samples, they do not pose any serious concern for human health [38].

Table 3. Range of studied PAHs in urban honey.

PAHs (µg/kg)	Country (Number of Samples) [Reference]	
	Serbia (*n* = 23) [16]	**Romania (*n* = 18) [38]**
Ace	<0.3–2.2	4.0–284.0
Acy	nd	2.0–32.0
An	<0.04–0.36	472.0–653.0
B[ghy]P	<2.0	<LOQ-1.0
B[α]An	<0.1–0.4	<LOQ
B[α]Py	<0.2–0.5	1.0–141.0
B[β]Fl	<0.3	nd
B[κ]Fl	<0.06–0.32	6.0–155.0
Chry	<0.9–1.2	<LOQ
dB[αh]An	0.7–1.8	<LOQ-59.0
Fl	<0.2–0.3	5.0–31.0
F	<0.2–0.8	1.0–163.0
I [123-cd]Py	<0.2–0.4	0.8–23.0
Np	<0.8–11.6	170.0–665.0
Ph	0.2–1.6	43.0–625.0
Py	<0.8–1.5	5.0–89.0

Ace: acenaphthene; Acy: acenaphthylene; An: anthracene; B[ghy]P: benzo[ghy]perylene; B[α]An: benzo[α]anthracene; B[α]Py: benzo[α]pyrene; B[β]Fl: benzo[β]fluoranthene; B[κ]Fl: benzo[κ]fluoranthene; Chry: chrysene; dB[αh]An: dibenzo[α,h]anthracene; Fl: fluoranthene; F: fluorene; I [123-cd]Py: indeno [1,2,3-cd]pyrene; Np: naphthalene; Ph: phenanthrene; Py: pyrene; nd: not determined; LOQ: limit of quantitation.

In a study from Australia [4], in 23 samples of urban, rural or mixed honey, only four PAHs were found in one or more. Naphthalene is the most frequent in the samples analyzed. The sample with the highest concentration of PAH is 0.002 mg/kg and is from urban honey.

On the other hand, PCBs are contaminants that can form accumulations in adipose tissues among them. This is because they have great stability and lipophilic properties [40]. However, not much information has been found on PCBs in honey from urban areas, which may be because the lipid levels of honey are low. Table 4 reflected values of PCBs from urban honey in Turkey during three consecutive years observing the same 6–7 honey samples found [13,41,42]. Sari et al. [13] observed that levels of PCBs in honey are lower compared to the PCBs content in the bees themselves.

Table 4. Range of studied PCBs in Turkish urban honey.

PCBs	*n*	Mean ± Standard Deviation (SD)	Reference
Σ(46)PCBs	7	106.35 ± 21.60	[13]
Σ(50)PCBs	7	104.89 ± 31.48	[41]
Σ(14)PCBs	6	13.0 ± 4.8	[42]

3.4. Pesticides

There is little information and few studies that analyze pesticides in this type of honey. Neonicotinoids are one of the most demanded and currently used pesticides [43]. The results of the study by Kavanagh et al. [44] concluded that modified environments are more harmful to bees, concerning exposure to neonicotinoids. Regarding its content detected in Irish honey, it is present in urban ecosystems (n = 10). Clothianidin and thiacloprid are the most common in this study, with a value below 0.05 mg/kg. They are not considered to be a risk to human health [44]. Although previous results show that urban areas have a positive relationship with honey quality in terms of phenolic content, this may be offset by the exposure of bees to these pesticides [23]. However, the possible routes of contamination of these compounds need to be further investigated [44]. Another Australian study reported that neonicotinoids were not detected by LC-MS/MS in the analyzed food matrix [4].

Respect to organochlorine pesticides (OCPs), they are a serious danger to human health through the contamination of food. This is due to their toxicity, high accumulation and persistence in the environment [45]. The sum of 10 OCPs pesticides in honey has resulted in 41.83 $\pm$ 1.61 ng/g in the urban area. In addition, the risk of cancer due to the consumption on the analyzed samples was evaluated, and it was verified that there was no risk of cancer in both sampling areas [18]. Another current study of OCPs in Kentucky [25] provides evidence that 72% of urban samples analyzed (six samples of honeycombs and twelve of honey) exceeded one or more of the values obtained the tolerable daily intake (TDI) confirmed by the EPA [46]. Twenty OCPs have also been detected in the study by Jovetić et al. [16] below the LOQ (0.01 ng/g). Furthermore, a study carried out in the west of France shows that the concentrations of pesticides detected in rural honey are higher than from other environments, including urban ones [26]. A negligible number of pesticides have been detected using the GC-MS/MS method and only one of the 96 tested has been identified, cyhalothrin at a low level (0.01 mg/kg) [4]. It could be because urban green areas, in addition to being an attractive source of food for bees, are in this case favorable for beekeeping because pesticides are used in fewer quantities [10].

3.5. Microbiological Parameters

Microbial contamination of honey can be due to several sources: the digestive tract of the honeybee, the beekeeper, the production, processing or storage of honey, nectar, dust and pollen [47]. Most of the studies searched and found are not conclusive about the exclusive microbiological parameters of urban honey, but refer to honey from various flowers, both urban and rural. The samples analysed by Kavanagh et al. [23] reflected that the level of aerobic mesophiles, moulds and yeasts was low. In addition, it was observed that if they are left for 7 days at 27 °C, they can have effects on the microbiological stability of honey, due to a protein anchored in the internal membrane of these microbes (TAMB). The microbial load detected in the food matrix has been obtained by counting aerobic mesophilic bacteria using standard plate count agar (PCA) [22,23]. The microbiological status of urban honey in a Serbian study [22] obtained that the total number of all honey samples (n = 13) is <100 CFU/g, except for two samples from one area of Belgrade (3.25 $\times$ 10^3 CFU/g) and Arilje (2.85 $\times$ 10^3 CFU/g). Regarding the bacteria present, *Bacillus* spp. is found in four samples of urban honeys (three samples collected from Belgrade and one from the Čačak area). Sulfite-reducing *Clostridium* was <10 CFU/g in all honeys (n = 13). Salmonella spp. was not detected in any kinds of honey. The total number of moulds was <100 CFU/g, but the total number of yeasts was higher (6 $\times$ 10^2 and 4 $\times$ 10^2 in two samples from Belgrade). Finally, *C. botulinum* type E was only detected by PCR in a honey sample from Belgrade [22].

3.6. Total Phenolic Content

Regarding the total phenolic content (TPC) in this type of polyfloral honey, several significant differences have been observed compared to rural ones [20]. In comparison, urban honey had three times more polyphenols, also 50% more total phenolic content and antioxidant capacity. Preti and Tarola [20] attributed these last two data to the feeding of urban bees fed by cultivated flowers due to the lack of rain in 2019 in Italy. Preti and Tarola [20] shown that the total phenolic content (TPC) in the food matrix is 473.02 mg GAE/g (mg gallic acid equivalents per gram of honey) on average in two years of research. They exceed the biannual average of honey from rural and coastal environments, 349.85 and 372.065 mg GAE/g, respectively. Also, the antioxidant capacity of urban honey is higher compared to rural coastal or mountain honey with inhibition percentages of 28.245 and 23.425 (assay with DPPH and trial with ABTS, respectively) [20]. In a study carried out in Ireland [23], it was also found that rural honey has a lower TPC compared to urban honey (20.32 ± 11.54 versus 28.26 ± 13.63 mg/100 g, respectively). A higher TPC may be due to a greater diversity of floral resources in some urban landscapes. These plant species in the urban landscape contribute to a higher phenolic content in honey, being less abundant in most rural landscapes [48]. There is a relationship between phenolic content, antioxidant capacity and honey colour [20]. The darker honey usually has a higher phenolic content and antioxidant capacity [49]. However, another current study [21] refutes the information from the previous ones, including data on lower total phenolic content and lower total antioxidant capacity in urban versus rural honey in Poland.

4. Conclusions and Future Directions

The interest in the characterization of urban honey is due to its increasing consumption and beekeeping in recent years. Since 2005, urban beekeeping began to expand in various European countries before spreading into North America, Asia, Latin America, and Africa, due to keeping bees in urban spaces which help to their survival due to the reduced exposure to agricultural pesticides and limited assortment of plants for foraging, and the social benefits of beekeeping [50]. Nonetheless, the scientific literature is still scarce particularly with the establishment of key parameters to evaluate the quality of rural honey and its environmental settings. This last is reflected by Cobb [51] where the connection of humans and bees favored environmental, social and cultural values. Our work is intended to contribute in this regard by showing different physicochemical parameters in the food matrix, and the presence of six elements. Furthermore, the microbial load detected in this type of samples is reflected in this review by counting microorganisms. A higher content of yeasts has also been found with respect to mold growth, in addition to detecting *Bacillus* spp. bacteria, *Clostridium* sulfite-reducing *Clostridium* and *C. botulinum* type E in honey samples obtained in urban environments. This type of honey contains phenolic compounds (TPC) determined by its gallic acid level.

The bibliographic data obtained on the contamination of urban honey show that greater contamination by rural honey tends to predominate over them. There is a lack of literature that would allow more reliable and solid conclusions to be drawn on food safety in this type of honey. There is also a current gap in the legislation, which should be updated and adjusted to the biochemical reality of a product such as honey, which when produced in an urban environment acquires changing properties, which should be reflected in food legislation in general, and in that which regulates food safety in particular being connected with the Farm to Fork and The European Green Deal strategies' goals to make Europe the first climate-neutral continent by 2050. On the other hand, the future of this product should be related with the development of new tools focused to help decision-making optimization in beekeeping production, such as the study of De Meio Reggiani et al. [52], to create an evolutionary algorithm to make economic–financial decisions concerning the beekeeping activity.

Author Contributions: Conceptualization, D.Q. and J.M.S.; methodology, formal analysis, investigation, and data curation, D.Q., I.Z., J.M.S., M.-A.F.-Z. and H.B.; writing—original draft preparation, D.Q., I.Z., and J.M.S.; writing—review and editing, M.-A.F.-Z. and H.B.; funding acquisition, M.-A.F.-Z. and J.M.S. All authors have read and agreed to the published version of the manuscript.

Funding: This research was partially funded by World Sustainable Urban Food Centre of València (CEntro Mundial para la Alimentación urbana Sostenible; CEMAS), and by project-IVIA number 52203 (BonProfit Plan). The Plan against food waste in the Comunitat Valenciana is financed by the General CAP Agency (Conselleria de Agricultura, Desarrollo Rural, Emergencia Climática y Transición Ecológica, of the Generalitat Valenciana), and co-financed by the ERDF Funds.

Institutional Review Board Statement: Not applicable.

Informed Consent Statement: Not applicable.

Data Availability Statement: Not applicable.

Conflicts of Interest: The authors declare no conflict of interest.

References

1. Moore, L.J.; Kosut, M. Among the colony: Ethnographic fieldwork, urban bees and intra-species mindfulness. *Ethnography* **2014**, *15*, 516–539. [CrossRef]
2. Benjamin, A.; McCallum, B. *Bees in the City. The Urban Beekeepers' Handbook*; Guardian Books: London, UK, 2011.
3. Lorenz, S.; Stark, K. Saving the honeybees in Berlin? A case study of the urban beekeeping boom. *Environ. Sociol.* **2015**, *1*, 116–126. [CrossRef]
4. Hungerford, N.L.; Fletcher, M.T.; Tsai, H.H.; Hnatko, D.; Swann, L.J.; Kelly, C.L.; Tan, B.L. Occurrence of environmental contaminants (pesticides, herbicides, PAHs) in Australian/Queensland Apis mellifera honey. *Food Addit. Contam. B Surveill.* **2021**, *14*, 193–205. [CrossRef] [PubMed]
5. Devany, L.; Littlewood, J.R.; Curry, N.R.; Geens, A.J. Urban Beekeeping Schemes for Sustainable Food Production and Biodiversity. In COBRA 2006-Proceedings of the Annual Research Conference of the Royal Institution of Chartered Surveyors. Available online: https://www.researchgate.net/profile/John-Littlewood/publication/290802729_Urban_beekeeping_schemes_for_sustainable_food_production_and_biodiversity/links/5f69bf0d92851c14bc8e016c/Urban-beekeeping-schemes-for-sustainable-food-production-and-biodiversity.pdf (accessed on 22 December 2022).
6. Peterson Roest, B. Bees in the D: A message of conservation from an urban environment. *Challenges* **2019**, *10*, 19. [CrossRef]
7. Bennett, A.B.; Lovell, S. Landscape and local site variables differentially influence pollinators and pollination services in urban agricultural sites. *PLoS ONE* **2019**, *14*, e0212034. [CrossRef]
8. Siemaszko, M.; Zych, M. Urban ecosystems-a place for pollinators? A mini-review and social implications. *Miestų Želdynų Formavimas* **2017**, *14*, 193–201.
9. Llodra-Llabrés, J.; Cariñanos, P. Enhancing pollination ecosystem service in urban green areas: An opportunity for the conservation of pollinators. *Urban For. Urban Green.* **2022**, *74*, 127621. [CrossRef]
10. Sadowska, M.; Gogolewska, H.; Pawelec, N.; Sentkowska, A.; Krasnodębska-Ostręga, B. Comparison of the contents of selected elements and pesticides in honey bees with regard to their habitat. *Environ. Sci. Pollut. Res.* **2019**, *26*, 371–380. [CrossRef]
11. Garbuzov, M.; Ratnieks, F.L. Lattice fence and hedge barriers around an apiary increase honey bee flight height and decrease stings to people nearby. *J. Apic. Res.* **2014**, *53*, 67–74. [CrossRef]
12. Peters, K.A. Keeping bees in the city? Disappearing bees and the explosion of urban agriculture inspire urbanites to keep honeybees: Why city leaders should care and what they should do about it. *Drake J. Agri. L.* **2012**, *17*, 597–644.
13. Sari, M.F.; Gurkan Ayyildiz, E.; Esen, F. Determination of polychlorinated biphenyls in honeybee, pollen, and honey samples from urban and semi-urban areas in Turkey. *Environ. Sci. Pollut. Res.* **2020**, *27*, 4414–4422. [CrossRef] [PubMed]
14. Smith, K.E.; Weis, D.; Amini, M.; Shiel, A.E.; Lai, V.W.M.; Gordon, K. Honey as a biomonitor for a changing world. *Nat. Sustain.* **2019**, *2*, 223–232. [CrossRef]
15. Bartha, S.; Taut, I.; Goji, G.; Vlad, I.A.; Dinulică, F. Heavy metal content in polyfloralhoney and potential health risk. A case study of Copșa Mică, Romania. *Int. J. Environ. Res. Public Health* **2020**, *17*, 1507. [CrossRef] [PubMed]
16. Jovetić, M.S.; Redžepović, A.S.; Nedić, N.M.; Vojt, D.; Đurđić, S.Z.; Brčeski, I.D.; Milojković-Opsenica, D.M. Urban honey-the aspects of its safety. *Arh. Hig. Rada Toksikol.* **2018**, *69*, 264–274. [CrossRef] [PubMed]
17. Passarella, S.; Guerriero, E.; Quici, L.; Ianiri, G.; Cerasa, M.; Notardonato, I.; Protano, C.; Vitali, M.; Russo, M.V.; De Cristofaro, A.; et al. PAHs presence and source apportionment in honey samples: Fingerprint identification of rural and urban contamination by means of chemometric approach. *Food Chem.* **2022**, *382*, 132361. [CrossRef]
18. Günes, M.E.; Sari, M.F.; Esen, F. Organochlorine pesticides in honeybee, pollen and honey in Bursa, Turkey. *Food Addit. Contam. B Surveill.* **2021**, *14*, 126–132. [CrossRef]
19. Moher, D.; Liberati, A.; Tetzlaff, J.; Altman, D.G.; PRISMA Group. Preferred reporting items for systematic reviews and meta-analyses: The PRISMA statement. *Ann. Intern. Med.* **2009**, *151*, 264–269. [CrossRef]
20. Preti, R.; Tarola, A.M. Polyfloral honey from urban beekeeping: Two-year case study of polyphenols profile and antioxidant activity. *Br. Food J.* **2021**, *123*, 4224–4239. [CrossRef]
21. Nicewicz, A.W.; Nicewicz, Ł.; Pawłowska, P. Antioxidant capacity of honey from the urban apiary: A comparison with honey from the rural apiary. *Sci. Rep.* **2021**, *11*, 9695. [CrossRef]
22. Matović, K.; Ćirić, J.; Kaljević, V.; Nedić, N.; Jevtić, G.; Vasković, N.; Baltić, M.Ž. Physicochemical parameters and microbiological status of honey produced in an urban environment in Serbia. *Environ. Sci. Pollut. Res.* **2018**, *25*, 14148–14157. [CrossRef]
23. Kavanagh, S.; Gunnoo, J.; Passos, T.M.; Stout, J.C.; White, B. Physicochemical properties and phenolic content of honey from different floral origins and from rural versus urban landscapes. *Food Chem.* **2019**, *272*, 66–75. [CrossRef] [PubMed]

24. Codex Alimentarius Commission Standards. *CODEX STAN 12-1981. Revisions 1987, 2001. Amended 2019*; FAO/WHO Food Standards Programme: Rome, Italy, 2019.
25. Lambert, O.; Piroux, M.; Puyo, S.; Thorin, C.; Larhantec, M.; Delbac, F.; Pouliquen, H. Bees, honey and pollen as sentinels for lead environmental contamination. *Environ. Pollut.* **2012**, *170*, 254–259. [CrossRef] [PubMed]
26. Sheldon, M.; Pinion, C., Jr.; Klyza, J.; Zimeri, A.M. Pesticide contamination in Central Kentucky urban honey: A pilot study. *J. Environ. Health* **2019**, *82*, 8–13.
27. Gałczyńska, M.; Gamrat, R.; Bosiacki, M.; Sotek, Z.; Stasińska, M.; Ochmian, I. Micro and macroelements in honey and atmospheric pollution (NW and Central Poland). *Resources* **2021**, *10*, 86. [CrossRef]
28. Batelková, P.; Borkovcová, I.; Čelechovská, O.; Vorlová, L.; Bartáková, K. Polycyclic aromatic hydrocarbons and risk elements in honey from the South Moravian region (Czech Republic). *Acta Vet. Brno* **2012**, *81*, 169–174. [CrossRef]
29. Hungerford, N.L.; Tinggi, U.; Tan, B.L.; Farrell, M.; Fletcher, M.T. Mineral and Trace element analysis of Australian/Queensland Apis mellifera honey. *Int. J. Environ. Res. Public Health* **2020**, *17*, 6304. [CrossRef]
30. Borsuk, G.; Sulborska, A.; Stawiarz, E.; Olszewski, K.; Wiącek, D.; Ramzi, N.; Nawrocka, A.; Jędryczka, M. Capacity of honeybees to remove heavy metals from nectar and excrete the contaminants from their bodies. *Apidologie* **2021**, *52*, 1098–1111. [CrossRef]
31. Conti, M.E.; Canepari, S.; Finoia, M.G.; Mele, G.; Astolfi, M.L. Characterization of Italian multifloral honeys on the basis of their mineral content and some typical quality parameters. *J. Food Compos. Anal.* **2018**, *74*, 102–113. [CrossRef]
32. Perugini, M.; Manera, M.; Grotta, L.; Abete, M.C.; Tarasco, R.; Amorena, M. Heavy metal (Hg, Cr, Cd, and Pb) contamination in urban areas and wildlife reserves: Honeybees as bioindicators. *Biol. Trace Elem. Res.* **2011**, *140*, 170–176. [CrossRef]
33. Skorbiłowicz, E.; Skorbiłowicz, M.; Cieśluk, I. Bees as bioindicators of environmental pollution with metals in an urban area. *J. Ecol. Eng.* **2018**, *19*, 229–234. [CrossRef]
34. Mejías, E.; Garrido, T. Analytical procedures for determining heavy metal. In *Honey Analysis*; de Alencar, V., Ed.; INTECH: London, UK, 2017; pp. 311–324.
35. European Union. Commission Regulation (EU) 2018/73 of 16 January 2018 amending Annexes II and III to Regulation (EC) No 396/2005 of the European Parliament and of the Council as regards maximum residue levels for mercury compounds in or on certain products. *Off. J. Eur. Union* **2018**, *L13*, 8–20.
36. Bilandžić, N.; Sedak, M.; Đokić, M.; Kolanović, B.S.; Varenina, I.; Božić, Đ.; Simic, B.; Koncurat, A.; Brstilo, M. Lead content in multifloral honey from central Croatia over a three-year period. *Bull. Environ. Contam. Toxicol.* **2012**, *88*, 985–989. [CrossRef]
37. European Union. Commission Regulation (EU) 2021/1317 of 9 August 2021 amending Regulation (EC) No 1881/2006 as regards maximum levels of lead in certain foodstuffs. *Off. J. Eur. Union* **2021**, *L286*, 1–4.
38. Dobrinas, S.; Birghila, S.; Coatu, V. Assessment of polycyclic aromatic hydrocarbons in honey and propolis produced from various flowering trees and plants in Romania. *J. Food Compos. Anal.* **2008**, *21*, 71–77. [CrossRef]
39. Falco, G.; Domingo, J.L.; Llobet, J.M.; Teixido, A.; Casa, C.; Muller, L. Polycyclic aromatic hydrocarbons in foods: Human exposure through the diet in Catalonia, Spain. *J. Food Prot.* **2003**, *66*, 2325–2331. [CrossRef] [PubMed]
40. Abella, V.; Pérez, T.; Scotece, M.; Conde, J.; Pirozzi, C.; Pino, J.; Lago, F.; González-Gay, M.A.; Mera, A.; Gómez, R.; et al. Pollutants make rheumatic diseases worse: Facts on polychlorinated biphenyls (PCBs) exposure and rheumatic diseases. *Life Sci.* **2016**, *157*, 140–144. [CrossRef]
41. Sari, M.F.; Esen, F.; Tasdemir, Y. Levels of polychlorinated biphenyls (PCBs) in honeybees and bee products and their evaluation with ambient air concentrations. *Atmos. Environ.* **2021**, *244*, 117903. [CrossRef]
42. Sari, M.F.; Esen, F. Concentration levels and an assessment of human health risk of polycyclic aromatic hydrocarbons (PAHs) and polychlorinated biphenyls (PCBs) in honey and pollen. *Environ. Sci. Pollut. Res. Int.* **2022**, *29*, 66913–66921. [CrossRef] [PubMed]
43. Simon-Delso, N.; Amaral-Rogers, V.; Belzunces, L.P.; Bonmatin, J.M.; Chagnon, M.; Downs, C.; Furlan, L.; Gibbons, D.W.; Giorio, C.; Girolami, V.; et al. Systemic insecticides (neonicotinoids and fipronil): Trends, uses, mode of action and metabolites. *Environ. Sci. Pollut. Res.* **2015**, *22*, 5–34. [CrossRef]
44. Kavanagh, S.; Henry, M.; Stout, J.C.; White, B. Neonicotinoid residues in honey from urban and rural environments. *Environ. Sci. Pollut. Res.* **2021**, *28*, 28179–28190. [CrossRef]
45. Shendy, A.H.; Al-Ghobashy, M.A.; Mohammed, M.N.; Alla, S.A.G.; Lotfy, H.M. Simultaneous determination of 200 pesticide residues in honey using gas chromatography–tandem mass spectrometry in conjunction with streamlined quantification approach. *J. Chromatogr. A* **2016**, *1427*, 142–160. [CrossRef] [PubMed]
46. USEPA IRIS. *Reference Dose (RfD): Description and Use in Health Risk Assessments, Background Document 1A, Integrated Risk Information System (IRIS)*; USEPA: Washington, DC, USA, 1993.
47. Gomes, S.; Dias, L.G.; Moreira, L.L.; Rodrigues, P.; Estevinho, L. Physicochemical, microbiological and antimicrobial properties of commercial honeys from Portugal. *Food Chem. Toxicol.* **2010**, *48*, 544–548. [CrossRef] [PubMed]
48. Kaluza, B.F.; Wallace, H.; Heard, T.A.; Klein, A.M.; Leonhardt, S.D. Urban gardens promote bee foraging over natural habitats and plantations. *Ecol. Evol.* **2016**, *6*, 1304–1316. [CrossRef] [PubMed]
49. Karabagias, I.K.; Dimitriou, E.; Kontakos, S.; Kontominas, M.G. Phenolic profile, colour intensity, and radical scavenging activity of Greek unifloral honeys. *Eur. Food Res. Technol.* **2016**, *242*, 1201–1210. [CrossRef]
50. Egerer, M.; Kowarik, I. Confronting the modern gordian knot of urban beekeeping. *Trends Ecol. Evol.* **2020**, *35*, 956–959. [CrossRef]

51. Cobb, A. Living with Bees: A Look into the Relationships between People and Native Bees in Western Nepal. Independent Study Project (ISP) Collection. 3181. Available online: https://digitalcollections.sit.edu/isp_collection/3181 (accessed on 22 December 2022).
52. De Meio Reggiani, M.C.; Villar, L.B.; Vigier, H.P.; Brignole, N.B. An evolutionary approach for the optimization of the beekeeping value chain. *Comput. Electron. Agric.* **2022**, *194*, 106787. [CrossRef]