



Antibiotic Residues in Filtered honeys

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ABSTRACT

In this study, tetracycline and streptomycin group antibiotic residues were investigated in packaged and open sold honey. For this purpose, a total of 60 honey samples, which were 30 of each were used as material. Honey samples were taken from various sales places located in Sivas province. ELISA method was used for the analysis and commercial test kits were used. According to the analysis results; tetracycline was found in 73.3% (22 samples) of the packaged honey and streptomycin was found in all samples. Tetracycline and streptomycin were determined as positive in open honeys were respectively 60% (18 samples) and 93.3% (28 samples). Tetracycline levels were between 0.12-371.44 ppb (mean 13.91 ± 12.33) in packaged honey and 0.02-13.32 ppb (mean 1.75 ± 0.5) in open honeys. Streptomycin levels were 1.30-250.2 ppb (mean 25.8 ± 10.8) in packaged honey and 0.19-22.71 ppb (mean 8.21 ± 5.2) in open honeys. Antibiotic residue was not found in one sample of open honeys. The findings suggest that, although illegal, some medicines are used in beekeeping or that bees are exposed to antibiotics that are added to the feed or water of other animals. These findings pose a potential risk to the consumer.

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Introduction

Beekeeping is an agricultural activity that brings economic aspects in the world and widely held in Turkey. According to Turkey Statistical Institute (TÜİK) data world honey production was 1,861 thousand tons and the hive presence was 91,000 (thousand units) and the yield per hive was determined as 20.4 kg in 2017. In terms of assets for hive; India first (12.8 million), China second (9.2 million), Turkey third (7.8 million), Iran fourth (7.3 million) and Ethiopia fifth (6.1 million) ranks. Honey yield per hive is reported to be 60.2 kg in China, 56.6 kg in Canada, 56.3 kg in Portugal, 42.4 kg in Uruguay and 41.1 kg in Brazil. In the same year honey yield per colony was determined to be 14.7 kg in Turkey (TÜİK, 2017).

Turkey ranks at 2nd after China in honey production. Especially the Aegean region, Eastern Black Sea and Mediterranean regions are suitable for beekeeping in terms of plant flora. According to TÜİK data; the number of beekeeping holdings was 81,108 (number), number of hives was 7,083 (thousand), honey production was 103,525 tons in 2014; the number of hives was 7,748 (thousand) and honey production was reported as 108,128 tons in 2015. The number of hives increased by 2% to 7,900 (thousand units) and honey production decreased by 2.2% to 105,727

tons in 2016. Honey production was 114,471 tons in 2017. The number of hives was 8.108.424 (units), honey production was 107.920 tons and honey yield per hive was 13.3 kg in 2018. Honey consumption is over 1 kg per person in our country. This amount is 0.05 kg in the world, 0.7 kg in EU countries, 0.2 kg in China, 0.9 kg in New Zealand and 0.6 kg in the USA (Anonim, 2019).

Honey "Is a natural product as plant nectars, secretions of living parts of plants or secretions of plant-sucking insects living on living parts of plants by combining them with their own substances after being collected by honeybees (*Apis mellifera* L.) and maturing by storing in honeycomb defined in the Turkish Food Codex (TGK, 2012).

Definition of honey in Turkish Standards (TS, 2002); The collection of nectars in the flowers of the plants or the sweet parts secreted by the living parts of the plants and some monogamous insects by their honeybees (*Apis mellifera* L.), a sweet product of dark consistency which occurs as a result of maturation and storage in the honeycomb eyes of their bodies.

According to resources of honey, flower honey (nectar honey), secretion honey (pine honey), poison honey (crazy

honey), artificial honey, feeding honey and express honey, according to production and market type; honeycomb, strained honey, honeycomb filtered honey, extra honey, press honey and filtered honey; according to color, water white, extra white, extra light amber and dark color classified. Depending on the plant pigments it contains, the colour of honey varies from water white to dark amber (TGK, 2012).

The plant flora and climate of the production region have an impact on the composition of honey. Honey generally contains 80% sugar and 17% water. The remaining 3% consists of minerals, vitamins, amino acids, colorants and enzymes. Honey is not suitable for microbial growth due to its high sugar content, low water activity and acidity (pH 3-4). Phenolic compounds in its composition (flavonoids, phenolic acid) give to honey antioxidant properties (TGK, 2012).

Honey is a natural food that can be consumed in any age group, except for those with diabetes and allergies and children under one-year-old. Food industry, pharmaceutical and cosmetic, as well as for the treatment of certain diseases (apitherapy) has a wide range of uses. Beside honey the bee products such as royal jelly, propolis, pollen and beeswax are also important for health and nutrition (Özmen and Alkin 2006; Anonim, 2014a; Ömür, 2015).

Drugs used against firstly varroa and juvenile rot, bee diseases and parasites lead to significant losses in beekeeping. Unnecessary or unconscious use of these drugs poses a potential risk to consumer health and economy. Antibiotic residues in foods cause allergic reactions, anaphylactic shock, nervous disorders, impaired intestinal flora, and resistance to bacteria in susceptible individuals. It has also been reported to have carcinogenic and teratogenic effects (Nisha, 2008; Kaftanoğlu, 2000; Al-Waili et al, 2012; Tayar and Yarsan, 2014; Kaya, 2018).

The tetracycline group of antibiotics (tetracycline, oxytetracycline, clortetracycline, doxycycline) are effective on Gram (+) and Gram (-) aerobic and anaerobic bacterias. Tetracycline's are broad-spectrum antibiotics. They produce bacteriostatic effects which inhibit bacterial cell protein synthesis. They are not suitable for use in pregnant women and children under 8 years of age because this group of antibiotics causes permanent discoloration of the teeth. Streptomycin group of antibiotics are classified into aminoglycosides. Antibiotics in this group are effective on Gram (-) bacteria. They show bactericidal effect by inhibiting protein synthesis (Kaya, 2000; Yarsan, 2018).

Sivas ranks at 6th after Ordu, Muğla, Adana, Aydın and Mersin provinces in honey production. The region is rich in plant flora. Divriği, Zara and Koyulhisar are the districts where intensive beekeeping is done. Honey production in Sivas province was 2,908 tons in 2010. This amount was determined as 3,039 tons in 2014. The number of hives was 219,942 (units), honey production was 2,861 tons in 2016; the number of hives was 215,878 (units) and the production of honey was 3,715 tons in 2017. There are 3,427 enterprises related to beekeeping in Sivas (Anonim, 2014b; Arslan, 2016; TÜİK, 2017).

In this study, branded and open 60 strained honey samples taken from various outlets in Sivas province were examined for tetracycline and streptomycin group antibiotic residues. The data obtained were evaluated in terms of food safety and public health considering the

standard values and public health considering the standard values.

Materials and Methods

In this study, a total of 60 strained honey samples, 30 of which were packaged and branded and 30 of which were open, were used as material. Honey samples were collected periodically from the sales places (market, grocery, street market, wholesaler) in Sivas province in March-May 2018 period. Disposable sterile falcon tubes (50 ml) were used for sampling. Packed honeys were selected from different brands and purchased in their original form. Samples were brought to the laboratory of the Department of Biochemistry, Faculty of Veterinary Medicine, Sivas Cumhuriyet University and analysed on the same day. Honey samples were kept in a cool environment during this process.

Tetracycline and streptomycin group antibiotic levels in honey samples were determined by Enzyme Linked Immunosorbent Assay (ELISA). The test kits which are Sinogeneclon Streptomycin ELISA (SG-4011) and Sinogeneclon Tetracycline ELISA (SG-4021) were used in the analyses. Analyses were performed according to the kit procedures. Descriptive statistics of tetracycline and streptomycin levels were determined in SPSS 22.00 package program (SPSS, 2014).

Results

The statistical values and percentage (%) distribution of tetracycline and streptomycin levels detected in packaged and open sold filter honeys are given in Table 3-6.

According to the analysis results; 73.3% (22 samples) of tetracycline and 100% (30 samples) of streptomycin were determined in packaged honeys. Ratios of tetracycline and streptomycin were 60% (18 samples) and 93.3% (28 samples) respectively in open honey samples. Tetracycline level was determined between 0.12-371.44 ppb (mean 13.91 ± 12.33) in packaged honey and 0.02-13.32 ppb (mean 1.75 ± 0.5) in open ones. Streptomycin levels were found to be 1.30-250.2 ppb (mean 25.8 ± 10.8) in packaged honey and 0.19-22.71 ppb (mean 8.21 ± 5.2) in the open ones. Antibiotic residue was not found in only one sample of open honeys.

Discussion

In this study, antibiotic residues and levels of tetracycline and streptomycin group were investigated in packaged and open-sold filtered honeys. A total of 60 honey samples, 30 piece of each variety, were used as material. Samples were taken from sales places located in Sivas province. ELISA method was used in the analysis via commercial test kits.

According to the analysis findings; residues of tetracycline 22 (73.3%) and 100% (30 samples) of streptomycin group antibiotic were detected in packaged honey. Levels of tetracycline and streptomycin were determined between 0.12-371.44 ppb (mean 13.91 ± 12.33) and 1.30-250.2 ppb (mean 25.8 ± 10.8) respectively in these sample. Samples of 18 (60%) were positive for tetracycline and samples of 28 (93.3%) were positive for

streptomycin residue in open honeys. Residue levels were between 0.02-13.32 ppb (mean 1.75 ± 0.5) and 0.19-22.71 ppb (mean 8.21 ± 5.2) in the same order. Tetracycline and streptomycin residue were not found in one sample of open honeys (Table 3-6).

The studies were conducted level of tetracycline <0.04-42 ppb and level of streptomycin <10 ppb in honey in Turkey of different regions in different years (Sunay, 2006; Gül, 2008; Seğmenoğlu, 2013; Derebaşı et al., 2014; Özkan et al., 2015; Korkmaz et al., 2017; Bağcı, 2019). Tetracycline content of examined honey samples was 3.3-58.3%; streptomycin ratio was determined between 5-52.5% (Table 1).

In this study, levels of tetracycline and streptomycin and positivity rates were found higher in the packaged and open filtered honeys than the results of these researchers. The determined values do not coincide with the findings of the researchers (Güneş et al., 2009; Polat, 2011; Kutlu et al., 2017; Saygılı, 2017) who reported that tetracycline and

streptomycin residues were not found in honey. Differences between research results can be explained by the fact that honeys of different origins and origin belong to different regions the number of samples and method differences.

When the studies conducted in other countries are examined; Sarıdaki-Papakonstadinou et al. (2006) tetracycline levels in honey samples of different properties 0.018-0.057 mg/kg (Greece); Diserens (2007) 0.5 g/kg (Switzerland); Bonvehi and Gutierrez (2008) 15-920 µg/kg (Spain); Taokaenchan and Sangrichan (2010) 7.18-14.06 mg/kg (Thailand); Zai et al. (2013) 3.67 µg/ml (Pakistan); Berehoiu et al. (2013) 13,21-18,33 ppb (Romania); Mahmoudi et al. (2014b) 0.2-6.2 µg/kg (Iran); Saleh et al. (2016) found that they were 2,330 µg/kg (Yemen). Tetracycline rates in honey samples were determined between 4-100% (Reybroeck, 2003, Sarıdaki-Papakonstadinou et al., 2006; Bonvehi and Gutierrez, 2008; Baggio et al., 2009; Berehoiu et al., 2013; Mahmoudi et al., 2014b). (Table 2).

Table1. Antibiotic residue levels in different types of honey in studies in Turkey

Province	n	Antibiotic	n ₁ (%)	Residue level	Reference
Different provinces	1714	Sulphamethazine	%10	<11 ppb	Sunay (2006)
	1421	Tetracycline	%15	<13.65 ppb	
	91	Streptomycin	%5-10	<10 ppb	
İstanbul	100	Naphthalene	1	1.13µg/kg	Beyoğlu and Omurtag (2007)
Ege region	103	Sulfonamide	%23		Uludağ (2008)
İstanbul	610	Sulfonamide	%29,5		Gül (2008)
		Tetracycline	%3,3		
		Streptomycin	%11,9		
Güney Marmara	50	Erythromycin	4(%8)	50-1776 ng/kg	Güneş et al. (2008)
Güney Marmara	50	Oxytetracycline Sulfanamid	n.d.	n.d.	Güneş et al. (2009)
İzmir	10	Sulfadiazine	10	0.017-0.643 ppm	Özgenç (2011)
		Sulphamethazine		0.006-0.162 ppm	
İzmir	536	Sulfanamid	126		Erdoğdu et al. (2011)
Güney Marmara		Chloramphenicol Sulphonamide Tetracycline		n.d.	Polat (2011)
Different provinces	56	Streptomycin	4		Seğmenoğlu (2013)
Ankara	120	Naphthalene	11(%9,16)	1.1-6.2 ppb	Şireli (2013)
Different provinces and counties	98	Chloramphenicol	7	0-1.27 ppb	Toptancı (2013)
Karadeniz region	209	Streptomycin	13		Derebaşı et al. (2014)
		Sulfonamide	59		
		Tetracycline	7		
Ardahan ve ilçeleri	180	Streptomycin	68 (%37,7)	1.79 ppm	Özkan et al. (2015)
		Sulfanamid	94 (%52,2)	1.19 ppm	
Bitlis	20	Tetracycline Sulfanamid		n.d.	Kutlu et al. (2017)
Ege region	59	Tetracycline	35(%35)	6-42 ppb	Korkmaz et al. (2017)
		Sulfanamid	31	3-32 ppb	
Kırklareli	57	Streptomycin Chloramphenicol Tetracycline		n.d.	Saygılı (2017)
Different provinces	90	Naphthalene	1	115.23 ppb	Gölge et al. (2017)
Muğla and counties	84	Tetracycline	49 (%58,3)	<0.04-0.391 ppb	Bağcı (2019)
		Sulphamethazine	84(%10)	<10 ppb	
Antalya	30	Naphthalene	3	3.0-8.9 µg/kg	Çakar and Gürel (2019)

n: number of sample, n₁: positive sample, n.d. : not detected

Table 2. Antibiotic residue levels in different types of honey in studies conducted in various countries

Country	n	Antibiotic	n ₁ (%)	Residue Level	Reference
Belgium	108	Streptomycin	51(%47)		Reybroeck (2003)
	98	Tetracycline	29(%30)		
	248	Streptomycin	4(%1,6)		
	72	Tetracycline	2(%2,8)		
Holland	186	Dihydrostreptomycin	%26		Brujnsvoort et al. (2004)
Switzerland	75	Chloramphenicol	13(%17)	0,4-0,6 µg/kg	Ortelli et al. (2004)
Greece	251	Tetracycline	%97	0,018-0,057 mg/kg	Sarıdaki-Papakonstadinou et al. (2006)
		Oxytetracycline	%94	0,023-0,335 mg/kg	
		Doxycycline	%90	0,018-0,190 mg/kg	
		Chlortetracycline	%96	0,013-0,393 mg/kg	
Switzerland	3855	Streptomycin		3,0-10,82 g/kg	Diserens (2007)
		Sulfanamid		5,0 g/kg	
		Tetracycline		5,0 g/kg	
		Chloramphenicol		0,1-169 g/kg	
Spain	567	Sulfonamide	68(%12)	15-920 µg/kg	Bonvehi and Gutierrez (2008)
		Tetracycline	24 (%4)	n.d.	
		Chloramphenicol			
Italy	4084	Sulfonamide	%10,6		Baggio et al. (2009)
		Tetracycline	%4,2		
		Streptomycin	%2,8		
		Chloramphenicol	%1,8		
		Tylosin	%5,2		
Spain	16	Erythromycin		8,6 µg/kg	Vidal et al. (2009)
		Sarafloksasin		14,6 µg/kg	
		Tylosin	3	3,2 µg/kg	
		Sulfadimidine	1	iz mikt.	
		Sulfaclopridosine			
Thailand	6	Oxytetracycline	4	60,15-106,9 mg/kg	Taokaenchan and Sangrichan (2010)
		Tetracycline	2	7,18-14,06 mg/kg	
		Chlortetracycline		n.d.	
India	12	Oxytetracycline	6 (%50)	27,1-250,4 µg/kg	Johnson and Jadon (2010)
Bosnia Herzegovina	46		-	n.d.	Mujic et al. (2011)
Pakistan	100	Streptomycin		1,42 µg/mL	Zai et al. (2013)
		Tetracycline	18	3,67 µg/mL	
		Streptomycin		12,02 µg/mL	
		Tetracycline		16,31 µg/mL	
Romania	18	Streptomycin		42,77-51,49 ppb	Berehoiu et al. (2013)
		Tetracycline	18(%100)	13,21-18,33 ppb	
		Erythromycin		0,06-0,27 ppb	
Iran	145	Oxytetracycline	34(%23,4)	5,32-369,1 µg/kg	Mahmoudi et al. (2014a)
Iran	135	Tetracycline	19 (%14)	0,2-6,2 µg/kg	Mahmoudi et al. (2014b)
		Gentamycin	25 (%17)	0,6-72,1 µg/kg	
Algeria	36	Oxytetracycline		0,03 ppb	Draiaia et al. (2015)
		Tetracycline	2	n.d.	
		Streptomycin		n.d.	
Serbia	193		5 (%2,59)		Apic et al. (2015)
India	42	Oxytetracycline	42(%100)	0,05-0,17 µg/kg	Rao et al. (2015)
Italy	74	Sulfanamid	9(%12)	2 µg/kg	Galarini et al. (2015)
Pakistan	100	Penicillin	5 (%5)	1,76-4,86 mg/kg	Rahman (2016)
		Streptomycin	6 (%6)	1,12-6,65 mg/kg	
		Oxytetracycline	7 (%7)	1,12-6,42 mg/kg	
Yemen	16	Oxytetracycline		3,430-13,800 µg/kg	Saleh et al. (2016)
		Tetracycline		2,330 µg/kg	
		Oxytetracycline		7,140 µg/kg	
		Tetracycline		2,850 µg/kg	
India	150	Oxytetracycline	%15,3	9-69 ng/g	Kumar et al. (2019)
		Erythromycin	%5,3	78,8 ng/g	
		Chloramphenicol		n.d.	

n: number of sample, n₁: positive sample, n.d.: not detected

Table 3. The level of tetracycline (ppb) and percentage (%) of distribution in packaged honey samples

Tetracycline	n	%	Min.	Max.	Mean±SE
0	8	%26.7	0	0	0
0-0.05	-	-	-	-	-
0.05-0.15	1	%3.3	0.12	0.12	0.12
0.15-0.45	1	%3.3	0.18	0.18	0.18
0.45-1.35	3	%10	0.85	1.24	1.002±0.12
1.35-4.05	15	%50	1.51	3.79	2.41±0.19
4.05>	2	%6.7	6.4	371.44	188.92±182.51
Total	30	%100	0.12	371.44	13.91±12.33

SE: Standart Error

Table 4. The level of tetracycline (ppb) and percentage (%) of distribution in open honey samples

Tetracycline	n	%	Min.	Max.	Mean±SE
0	12	%40	-	-	-
0-0.05	2	%6.7	0.02	0.04	0.03±0.007
0.05-0.15	-	-	-	-	-
0.15-0.45	2	%6.7	0.23	0.44	0.33±0.1
0.45-1.35	2	%6.7	0.94	0.96	0.94±0.01
1.35-4.05	8	%26.7	1.52	3.46	2.35±0.2
4.05>	4	%13.3	5.01	13.32	7.80±1.9
Total	30	%100	0.02	13.32	1.75±0.5

Table 5. The level of streptomycin (ppb) and percentage (%) of distribution in packaged honey samples

Streptomycin	n	%	Min.	Max.	Mean±SE
0-0.1	-	-	-	-	-
0.1-0.3	-	-	-	-	-
0.3-0.9	-	-	-	-	-
0.9-2.7	3	%10	1.30	2.09	1.75±0.2
2.7-8.1	6	%20	6.35	7.8	7.05±0.2
8.1>	21	%70	8.73	250.2	34.59±15.1
Total	30	%100	1.30	250.2	25.8±10.8

Table 6. The level of streptomycin level (ppb) and percentage (%) of distribution in open honey samples

Streptomycin	n	%	Min.	Max.	Mean±SE
0	2	%6.7	-	-	-
0-0.1	-	-	-	-	-
0.1-0.3	1	%3.3	0.19	0.19	0.19
0.3-0.9	-	-	-	-	-
0.9-2.7	1	%3.3	2.66	2.66	2.66
2.7-8.1	12	%40	3.63	7.9	5.43±1.46
8.1>	14	%46.7	8.99	22.71	12.74±3.69
Total	30	%100	0.19	22.71	8.21±5.2

In this study, although the levels of tetracycline detected in the filtered honey were lower than the results of some researchers (Diserens, 2007; Taokaenchan and Sangrichan, 2010; Zai et al., 2013; Saleh et al., 2016), were higher than some researchers (Saridaki-Papakonstadinou et al., 2006; Bonvehi and Gutierrez, 2008; Berehoiu et al., 2013; Mahmoudi et al., 2014b).

The level of streptomycin in honey examined by Diserens (2007) 3.0-10.82 g/kg, Zai et al. (2013) 1.42-12.02 µg/g, Berehoiu et al. (2013) 42.77-51.49 ppb, Rahman (2016) found that between 1.12-6.65 mg/kg. The rate of streptomycin in honey was determined to be between 1.6-100% in studies (Reybroeck, 2003; Berehoiu et al., 2013; Rahman, 2016). In contrast to these studies, some researchers (Draiaia et al., 2015) reported that there were no residues of tetracycline and streptomycin in honey (Table 2).

In this study, streptomycin levels detected in strained honeys were found to be lower than those of some researchers (Diserens, 2007; Zai et al., 2013) and higher than the results of some studies (Berehoiu et al., 2013, Rahman, 2016). The determined values do not correlate with the findings of the researchers (Draiaia et al., 2015) who reported that they did not detect tetracycline and streptomycin in honey. The levels of tetracycline and streptomycin detected in honey samples were lower than those reported in these studies.

The European Union (EU) does not allow the use of medicines in beekeeping except for some antivarroa medicines. Maximum residue limits (MRLs) specifies for approved drugs only at the standard. MRL was not given for tetracycline and streptomycin group antibiotics. The residue level is limited to 10 ppb for drugs that do not specify MRL if honey is exported from other countries. However, in some countries (Switzerland, United

Kingdom, Belgium, USA, Canada, Australia, India), a limit value (0.01-0.05 mg / kg) was defined as “action limit” for each antibiotic group (EU, 2010).

Honey relevant legislation for Turkey prepared in line with the EU is given in “Turkish Food Codex Honey Notification (TGK, 2012)”. The criteria stated in the “Turkish Food Codex on Classification of Pharmacologically Active Substances in Animal Foods and Maximum Residue Limits Regulation (TGK, 2017) are taken into consideration for veterinary drug residues in honey and other bee products. The regulation does not provide MRL for tetracycline and streptomycin antibiotics in honey.

When the research findings are examined; one sample of packaged honey tetracycline (371.44 ppb), streptomycin levels in 2 samples (250.20 ppb and 236.20 ppb) were higher than the values determined in other samples. Tetracycline was detected in one sample, streptomycin in 17 samples in packaged honey; tetracycline level was determined in one sample and streptomycin level was determined above 10 ppb in 10 samples in open honey. Two in terms of tetracycline and 27 samples in terms of streptomycin residue strains of analysed honey samples did not comply with the limit values (10 ppb) reported by EU. Antimicrobial residue was not detected in only one sample from the examined filter honeys (Table 3-6).

Conclusion

The findings suggest that, although illegal, some medicines are used in beekeeping or that bees are exposed to antibiotics that are added to the feed or water of other animals. In this study, the residue level was found to be over 10 ppb in almost half of the samples examined. Streptomycin levels were generally higher in the same sample except for a few samples. In addition, the residual level and positivity rate of packaged honey is higher. These findings pose a potential risk to the consumer. In this context, it would be beneficial to take the following measures.

- New legislation on honey should be introduced.
- Those interested in beekeeping should do this work consciously.
- Certified manufacturing must be mandatory.
- Drug sales should be controlled.
- Legal audits should be made more frequent by the competent authorities.
- Necessary sanctions should be applied when residues are detected above the tolerance level.

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References

Al-Waili N, Salom K, Al-Ghamdi A, Ansari MJ. 2012. Antibiotic, pesticide and microbial contaminants of honey: human health hazards. The Scientific World Journal, DOI: <https://doi.org/10.1100/2012/930849>

- Anonim 2014a. Arıcılık ve Bal Raporu. Ünye Ticaret Borsası, Kasım 2014, Ordu. <http://www.bal-mer.com/Files/files/dokumanlar/aricilik-ve-bal-raporu---unye-ticaret-borsasi/Ar%C4%B1c%C4%B1k%20ve%20Bal%20Raporu%20-%20C3%9Cnye%20Ticaret%20Borsas%C4%B1.pdf>, [Accessed: 10.10.2019]
- Anonim 2014b. Sivas Tarım Hayvancılık ve Gıda Sektörel Çalışma Grubu Raporu. Tarım İl Müdürlüğü, Sivas, Türkiye.
- Anonim 2019. Haygem. Tarım ve Orman Bakanlığı Hayvancılık Genel Müdürlüğü. Ocak 2019, Ankara, Türkiye. <http://www.etb.org.tr/media/raporlar/HAYGEM%20-%20Ocak%202019.pdf>, [Accessed: 10.10.2019]
- Apic J, Ljubojevic D, Prica N, Jaksic S, Ratajac R, Babic J, Zivkov-Balos M. 2015. Antibiotic residues in honey samples collected within one year period in AP Vojvodina, Serbia. The Serbian Journal of Agricultural Sciences, 64(3-4): 261-266.
- Arslan E. 2016. Sivas İli Arı Yetiştiriciliğinin Genel Yapısı ve Arıcılık Faaliyetleri. Yüksek Lisans Tezi, Fırat Üniversitesi Sağlık Bilimleri Enstitüsü, Elazığ, Türkiye.
- Baggio A, Gallina A, Benetti C, Mutinelli F. 2009. Residues of antibacterial drugs in honey from the Italian market. Food Additives and Contaminants: Part B, 2(1): 52-58. DOI: <https://doi.org/10.1080/02652030902897721>
- Bağcı H. 2019. Muğla Bölgesinde Üretilen Ballarda Antibiyotik Kalıntılarının Araştırılması. Yüksek Lisans Tezi, Afyon Kocatepe Üniversitesi Sağlık Bilimleri Enstitüsü, Afyonkarahisar, Türkiye.
- Berehoiu RT, Visovan DM, Popa CN. 2013. Study on the presence of antibiotic residues in honey intended for public consumption. Scientific Papers Series Management, Economic Engineering in Agriculture and Rural Development, 13(3): 305-308.
- Beyoğlu D, Omurtag GZ. 2007. Occurrence of naphthalene in honey consumed in Turkey as determined by high-pressure liquid chromatography. Journal of Food Protection, 70(7): 1735-1738. DOI: <https://doi.org/10.4315/0362-028X-70.7.1735>
- Bonvehi JS, Gutierrez AL. 2008. Residues of antibiotics and sulfonamides in honeys from Basque Country (NE Spain). Journal of the Science of Food and Agriculture, 89: 63-72. DOI: <https://doi.org/10.1002/jsfa.3411>
- Bruijnsvoort MV, Ottink SJ, Jonker KM, Boer E. 2004. Determination of streptomycin and dihydrostreptomycin in milk and honey by liquid chromatography with tandem mass spectrometry. Journal of Chromatography A, 1058(1-2): 137-142. DOI: <https://doi.org/10.1016/j.chroma.2004.07.101>
- Çakar E, Gürel F. 2019. Süzme ve petekli balların pestisit, naftalin ve antibiyotik kalıntılarını bakımından karşılaştırılması. Mediterranean Agricultural Sciences, 32(3): 453-459. DOI: <https://doi.org/10.29136/mediterranean.592492>
- Derebaşı E, Bulut G, Col M, Güney F, Nurdoğan Y, Ertürk E. 2014. Physico-chemical and residue analysis of honey from Black Sea region of Turkey. Fresenius Environmental Bulletin, 23(1): 10-17.
- Diserens J. 2007. Contaminants and residues in Food. Strategies (if any) to screen and analyze veterinary drug residues in food from animal origin. Proceedings of the 5th International Fresenius Conference Nestle Research Center; Lausanne, Switzerland. <http://www.biocop.org/.../ContaminantsResiduesinFood5thFreseniusppt.pdf>, [Accessed: 15.10.2019]
- Draiaia R, Chefrour A, Dainese N, Borin A, Manzinello C, Gallina A, Mutinelli F. 2015. Physicochemical parameters and antibiotics residuals in Algerian honey. African Journal of Biotechnology, 14(14): 1242-1251. DOI: <https://doi.org/10.5897/AJB2015.14456>
- Erdoğan AT, Coşkun Y, Güven İS. 2011. Tüketime sunulan ballarda sülfonamid türevi antibiyotiklerin kalıntılarının belirlenmesi. Bornova Veteriner Bilimleri Dergisi, 33(47): 37-44.

- EU, 2010. European Union. Commission Regulation (EU) No 37/2010 of 22 December 2009 on pharmacologically active substances and their classification regarding maximum residue limits in foodstuffs of animal origin. Official Journal of the European Union, L15:1-72. https://ec.europa.eu/health/sites/health/files/files/eudralex/vol-5/reg_2010_37/reg_2010_37_en.pdf, [Accessed: 15.10.2019]
- Galarini R, Saluti G, Giusepponi D, Rossi R, Moretti S. 2015. Multiclass determination of 27 antibiotics in honey. Food Control, 48: 12-24. DOI: <https://doi.org/10.1016/j.foodcont.2014.03.048>
- Gölge Ö, Hepsağ F, Kılınççeker O. 2017. Determination of naphthalene levels of honey in eastern mediterranean region. Adyütayam Dergisi, 5(2): 14-23.
- Gül A. 2008. Türkiye’de Üretilen Bazı Balların Yapısal Özelliklerinin Gıda Güvenliği Bakımından Araştırılması. Doktora Tezi, Mustafa Kemal Üniversitesi Fen Bilimleri Enstitüsü, Hatay, Türkiye.
- Güneş N, Cıbık R, Güneş ME, Aydın L. 2008. Erythromycin residue in honey from the Southern Marmara region of Turkey. Food Additives and Contaminants, 25(11): 1313-1317. DOI: <https://doi.org/10.1080/02652030802233472>
- Güneş ME, Güneş N, Cıbık R. 2009. Oxytetracycline and sulphonamide residues analysis of honey samples from Southern Marmara region in Turkey. Bulgarian Journal of Agricultural Science, 15(2): 163-167.
- Johnson S, Jadon N. 2010. Antibiotic residues in honey. Center for Science and Environment, India Habitat Centre, New Delhi. http://cdn.cseindia.org/userfiles/Antibiotics_Honey.pdf, [Accessed:15.10.2019]
- Kaftanoğlu O. 2000. III. Arıcılık Kongresi Değerlendirme Raporu. Teknik Arıcılık Dergisi, s.70.
- Kaya S. 2000. Antibiyotikler. In: Kaya S, Pirinççi İ, Bilgili A (Editörler). Veteriner Uygulamalı Farmakoloji. Cilt II, Ankara, Türkiye: Medisan Yayınevi. pp 247-420. ISBN: 975-7774-39-1
- Kaya S. 2018. Hayvansal gıdalarda ilaç kalıntıları ve tüketici sağlığı. International Journal of Scientific and Technological Research, 4(8): 28-37.
- Korkmaz SD, Küplülü Ö, Çil Gİ, Akyüz E. 2017. Detection of sulfonamide and tetracycline antibiotic residues in Turkish pine honey. International Journal of Food Properties, 20(S1): S50-S55. DOI: <https://doi.org/10.1080/10942912.2017.1288135>
- Kumar A, Gill JPS, Bedi JS, Chhuneja PK, Kumar A. 2020. Determination of antibiotic residues in Indian honeys and assessment of potential risks to consumers. Journal of Apicultural Research, 59(1): 25-34. DOI: <https://doi.org/10.1080/00218839.2019.1677000>
- Kutlu MA, Gül A, Özdemir FA, Kılıç Ö. 2017. Bitlis ili Hizan ilçesinde üretilen ballarda antibiyotik kalıntılarının belirlenmesi. Türk Tarım ve Doğa Bilimleri Dergisi, 4(4): 523-527.
- Mahmoudi R, Moosavy M, Norian R, Kazemi S, Nadari MRA, Mardani K. 2014a. Detection of oxytetracycline residues in honey samples using ELISA and HPLC methods. Pharmaceutical Sciences, 19(4): 145-150.
- Mahmoudi R, Norian R, Pajohi-Alamoti M. 2014b. Antibiotic residues in Iranian honey by ELISA. International Journal of Food Properties, 17(10): 2367-2373. DOI: <https://doi.org/10.1080/10942912.2013.809539>
- Mujic I, Alibabic V, Jokic S, Galijasevic E, Jukic D, Sekulja D, Bajramovic M. 2011. Determination of pesticides, heavy metals, radioactive substances, and antibiotic residues in honey. Polish Journal of Environmental Studies, 20(3): 719-724.
- Nisha AR. 2008. Antibiotic residues-a global health hazard. Veterinary World, 1(12): 375-377. DOI: 10.5455/vetworld.2008.375-377
- Ortelli D, Edder P, Corvi C. 2004. Analysis of chloramphenicol residues in honey by liquid chromatography-tandem mass spectrometry. Chromatographia, 59(1): 61-64. DOI: <https://doi.org/10.1365/s10337-003-0132-5>
- Ömür B. 2015. Karadeniz Bölgesinde Üretilen Kestane (*Castanea sativa* Mill.) Ballarının Biyokimyasal Özelliklerinin İncelenmesi. Yüksek Lisans Tezi, Ordu Üniversitesi Fen Bilimleri Enstitüsü, Ordu, Türkiye.
- Özgenç S. 2011. Süt ve Balda Sülfonamidlerin Kromatografik Tayini. Yüksek Lisans Tezi, Dokuz Eylül Üniversitesi Fen Bilimleri Enstitüsü, İzmir, Türkiye.
- Özkan O, Eşsiz D, Yazıcı K, Erdağ D. 2015. Ardahan ilinde üretilen ballarda antibiyotik kalıntı düzeylerinin araştırılması. Atatürk Üniversitesi Veteriner Bilimleri Dergisi, 10(2): 88-92. DOI: <https://doi.org/10.17094/avbd.31906>
- Özmen N, Alkın E. 2006. Balın antimikrobiyel özellikleri ve insan sağlığı üzerine etkileri. Uludağ Arıcılık Dergisi, 4: 155-160.
- Polat İ. 2011. Güney Marmara Bölgesinde Üretilen Bazı Balların Antimikrobiyal, Antioksidan Aktivitelerinin Pestisid ve Antibiyotik Kalıntılarının İncelenmesi. Yüksek Lisans Tezi, Balıkesir Üniversitesi Sağlık Bilimleri Enstitüsü, Balıkesir, Türkiye.
- Rahman KU. 2016. Study of Residual Antibiotics and Their Metabolites in Honey. Doctor of Philosophy in Chemistry, Institute of Chemical Sciences University of Peshawar, Pakistan.
- Rao CRM, Kumar LCA, Sekharan CB. 2015. Quantitative analysis of oxytetracycline residues in honey by high performance liquid chromatography. International Research Journal of Biological Sciences, 4(5): 59-65.
- Reybroeck W. 2003. Residues of antibiotics and sulphonamides in honey on the Belgian market. Apisacta, 38: 23-30.
- Saleh SMK, Mussaed AM, Al-Hariri FM. 2016. Determination of tetracycline and oxytetracycline residues in honey by high performance liquid chromatography. Journal of Agricultural Science and Technology B, 6: 135-139. DOI:10.17265/2161-6264/2016.02.009
- Saridaki-Papakonstadinou M, Andredakis S, Burriel A, Tsachev I. 2006. Determination of tetracycline residues in Greek honey. Trackia Journal of Sciences, 4(1): 33-36.
- Saygılı M. 2017. Kırklareli İlinde Arıcılık Faaliyeti Yapan Üreticilerden Toplanan Peteklerde Antibiyotik ve Pestisit Kalıntısı Aranması. Yüksek Lisans Tezi, Namık Kemal Üniversitesi Fen Bilimleri Enstitüsü, Tekirdağ, Türkiye.
- Seğmenoğlu MS. 2013. Ballarda streptomisin kalıntı taraması. AVKAE Dergisi, 3(1): 15-17.
- SPSS, 2014. IBM SPSS Statistics for Windows, Version 22.00. SPSS Inc., Chicago, IL, USA.
- Sunay AE. 2006. Balda antibiyotik kalıntısı sorunu. Uludağ Arıcılık Dergisi, 6(4): 143-148.
- Şireli T. 2013. Süzme Ballarda GC-MS Metodu ile Naftalin Kalıntısının İncelenmesi. Ankara Üniversitesi Bilimsel Araştırmalar Projesi Sonuç Raporu, BAP No: 12H3338002, Ankara, Türkiye.
- Taokaenchan N, Sangsrichan S. 2010. HPLC-Fluorescence detection method for quantitative determination of tetracycline antibiotic residues in honey. NU Science Journal, 6 (2): 147-55.
- Tayar M, Yarsan E. 2014. Veteriner Halk Sağlığı. Bursa, Türkiye: Dora Yayınevi. ISBN 978-605-4798-63-6.
- TGK, 2012. Türk Gıda Kodeksi. Bal Tebliği. Tebliğ No. 58/2012, Resmi Gazete, Tarih: 27 Temmuz 2012, Sayı: 28366, Başbakanlık Basımevi, Ankara, Türkiye. <https://www.resmigazete.gov.tr/eskiler/2012/07/20120727-12.htm>, [Accessed: 12.10.2019]
- TGK, 2017. Türk Gıda Kodeksi. Hayvansal Gıdalarda Bulunabilecek Farmakolojik Aktif Maddelerin Sınıflandırılması ve Maksimum Kalıntı Limitleri Yönetmeliği. Resmi Gazete, Tarih: 7 Mart 2017, Sayı: 30000, Başbakanlık Basımevi, Ankara, Türkiye. <https://www.resmigazete.gov.tr/eskiler/2017/03//20170307-4.htm>, [Accessed: 12.10.2019]

- Toptancı İ. 2013. Çiçek ve Salgı Ballarında Polisiklik Aromatik Hidrokarbon (PAH), Pestisit ve Antibiyotik Kalıntılarının GC/MS ve LC/MS ile Belirlenmesi. Doktora Tezi, Ankara Üniversitesi Fen Bilimleri Enstitüsü, Ankara, Türkiye.
- TS, 2002. Türk Standartları Enstitüsü. Bal Standardı. TS 3036, Ankara, Türkiye.
- TÜİK, 2017. Türkiye İstatistik Kurumu. Hayvansal Üretim İstatistikleri. 7 Şubat 2017, Sayı: 24655, Ankara, http://www.tuik.gov.tr/HbGetir.do?id=24655&tb_id=10, [Accessed:12.10.2019]
- Uludağ R. 2008. Ege Bölgesinde Tüketime Sunulan Ballarda Sülfonamid Kalıntılarının Araştırılması. Yüksek Lisans Tezi, Adnan Menderes Üniversitesi Sağlık Bilimleri Enstitüsü, Aydın, Türkiye.
- Vidal JLM, Aguilera-Luiz MDM, Romero-Gonzalez R, Frenich AG. 2009. Multiclass analysis of antibiotic residues in honey by ultra performance liquid chromatography-mass spectrometry. *Journal Agricultural and Food Chemistry*, 57(5): 1760-1767. DOI: <https://doi.org/10.1021/jf8034572>
- Yarsan E. 2018. Veteriner ilaçları ve ilaçtan kaynaklanan sorunlar. *Lalahan Hayvancılık Araştırma Enstitüsü Dergisi*, 58(3): 64-68.
- Zai IUM, Rehman K, Hussain and Shafqatullah A. 2013. Detection and quantification of antibiotics residues in honey samples by chromatographic techniques. *Middle-East Journal of Scientific Research*, 14(5): 683-687. DOI: 10.5829/idosi.mejsr.2013.14.5.2114