PAPER DETAILS

TITLE: Aqueous and ethanolic extracts of propolis for the control of tyramine production by

food-borne pathogens

AUTHORS: Aykut BURGUT

PAGES: 265-271

ORIGINAL PDF URL: https://dergipark.org.tr/tr/download/article-file/899371



International Journal of Agriculture, Environment and Food Sciences

e-ISSN : 2618-5946

DOI: 10.31015/jaefs.2019.4.11



Research Article

Int J Agric Environ Food Sci 3(4):265-271 (2019)

Aqueous and ethanolic extracts of propolis for the control of tyramine production by food-borne pathogens

Aykut Burgut^{1,*} 问

¹Department of Animal Science Technology, Faculty of Agriculture, University of Cukurova, Adana, Turkey

*Corresponding Author: burguta@cu.edu.tr

Abstract

The influences of aqueous and ethanolic extracts of propolis (1%) on growth of common Gram-negative (Salmonella Parathyphi A, Campylobacter jejuni, Yersinia enterocolitica and Klebsiella pneumoniae) and -positive (Listeria monocytogenes, Staphylococcus aureus and Enterococcus faecalis) food-borne pathogens and their biogenic amines (BAs) production were examined in tyrosine decarboxylase broth (TDB). The highest growth inhibitory activity was observed against Gram-negative S. Paratyphi A in the existence of ethanolic and aqueous extracts of propolis, with 2.49 and 1.9 log reduction, respectively. Ethanolic extracts of propolis were more effective than that of aqueous extract on growth inhibition of L. monocytogenes (p < 0.05). Both extracts of propolis had significant effect on reducing ammonia production by bacteria (p<0.05). Tyramine, dopamine, agmatine and spermine were major amines formed in TDB. Tyramine production was the lowest with S. Paratyphi A (1.94 mg/L) and highest with E. faecalis (254.93 mg/L). The existence of ethanolic propolis extracts in TDB led to significantly fewer tyramine production by Gram-positive S. aureus, L. monocytogenes and E. faecalis, and Gram-negative C. jejuni (p<0.05). Histamine produced lower than 1.3 mg/L by all food-borne pathogens. Ethanolic extracts of propolis generally led to lower histamine production by bacteria. The influence of propolis on BAs production varied according to type of extracts, specific BAs and bacterial strains. However, the aqueous of propolis generally showed a synergistic effect on most of BAs mainly tyramine production by bacteria. Thus, the use of propolis ethanolic extracts appeared to be more suitable than aqueous extract to control tyramine production in foods.

Keywords: Propolis, Tyramine, Food-borne pathogens, Food safety

Introduction

Food safety is a major public health concern worldwide (Liu et al., 2019). Food-borne illnesses are often related with pathogens, toxins and chemicals, and are a global public health problem for a variety of causes. New risks constantly occur while others are inhibited (Camino-Feltes et al., 2017). Pathogenic bacteria have a capacity to form BAs via amino acid decarboxylation action. Some bacteria species including *Bacillus, Citrobacter, Klebsiella, Escherichia, Proteus, Pseudomonas* and *Photobacterium* may decarboxylate one or more amino acids (Silla-Santos, 1996, Karovičová and Kohajdová, 2005).

pied in several toxicological symptoms which resulted in various kinds of foodborne illness (headaches, low blood pressure, heart palpitations, edema, vomiting, and diarrhea) (Maintz and Novak, 2007). Therefore, the existence of BAs can influence both the feature and the safety of foods (Gram and Dalgaard, 2002). BAs have been found in many foods including fish, meat, cheese, vegetables and wines (Lorenzo et al., 2007). Tyramine is known as the most commonly accumulated BAs in cheese (Fernandez et al., 2007). Tyramine can cause physiological reactions such as peripheral vasoconstriction, improved cardiac output, elevated respiration, increased blood glucose, and release of norepinephrine (Shalaby, 1996). In view of the fact that the detection of the "cheese reaction" hyperten-

Digestion of food having excessive levels of BAs are occu-

Cite this article as:

Burgut, A. (2019). Aqueous and ethanolic extracts of propolis for the control of tyramine production by food-borne pathogens. Int. J. Agric. Environ. Food Sci., 3(4), 265-271

DOI: https://dx.doi.org/10.31015/jaefs.2019.4.11

Year: 2019 Volume: 3 Issue: 4 (December) Pages: 265-271

Available online at : http://www.jaefs.com - http://dergipark.gov.tr/jaefs

Copyright © **2019** International Journal of Agriculture, Environment and Food Sciences (Int. J. Agric. Environ. Food Sci.) This is an open access article distributed under the terms of the Creative Commons Attribution 4.0 International (CC-by 4.0) Licens



Received: 01 September 2019 Accepted: 17 December 2019 Published: 24 December 2019

sive crisis caused by tyramine intake among individuals on monoamine oxidase inhibitor (MAOI) drugs, several studies have focused on the tyramine content in foods (Marcobal et al. 2012). Control of BAs is crucial to ensure the safety of fermented foods (Li et al., 2018). BAs production can be restricted by preventing bacterial proliferation or the decarboxylase action of bacteria (Wendakoon and Sakaguchi 1995).

Propolis is a natural constituent accumulated by bees from native flora (Majiene et al., 2007). Propolis have natural combinations of several secondary metabolites that exert a variety of bioactivity e.g. antibacterial, antiulcer, antioxidant, and anti-viral activities (De Figueiredo et al., 2015). Since propolis is safe for humans if extensive dose is not taken (Satoshi et al., 2005), it possesses a wide range of uses such as preservatives in food products (fruits, juice, soft drinks, fish and meat products) and also in veterinary pharmaceutical applications (Casquite et al. 2016). Antimicrobial activity of propolis is due to their primary ingredients of flavonoids, phenolic compounds diterpenic acids and aromatic acids (Afrouzan et al., 2018). Propolis extracts exhibited the highest antimicrobial activity towards the Gram-positive food-borne pathogen bacteria e.g. Bacillus cereus and S. aureus (Nedji and Loucif-Ayad, 2014). The propolis exerted a noticeable antibacterial activity against the Gram-positive strain (L. monocytogenes) and restricted action against Gram-negative Salmonella Enteritidis depending on different propolis dose (Temiz et al., 2011). Propolis extracts had an inhibitory effect towards S. aureus isolated from instant soups, although their antimicrobial effects varied depending on their geographical regions (Apaydın and Gümüş, 2018).

Although many studies have been done about the antibacterial properties of propolis, there are limited studies regarding its impact on tyramine and other BAs accumulation by bacteria. Thus, the aim of the study was to examine the impact of aqueous and ethanolic extracts of propolis on tyramine and other BAs produced by common Gram-negative and positive food-borne pathogens.

Material and Method

Food-borne pathogens

Enterococcus faecalis ATCC29212, *Staphylococcus aureus* ATCC29213, *Klebsiella pneumoniae* ATCC700603, *Campylobacter jejuni* ATCC 33560 and *Listeria monocytogenes* ATCC19112 were purchased from the American Type Culture Collection (Rockville, MD, USA). *Salmonella* Parathyphi A NCTC13 and *Yersinia enterocolitica* NCTC 11175 were provided from the National Collection of Type Cultures (London, UK, Özogul et al., 2011).

Preparation of propolis extracts

Propolis from *Apis mellifera* was obtained using a commercial plastic trap in August 2018 (Adana, Turkey). Crude propolis was ground into powder and extracted with ethanol (70%) or water (100%). They placed in daily shakable containers for 48 h. Solutions of propolis were prepared aseptically and protected from light. They were stored in a dark place at 4 °C until analysis.

Culture Conditions and Bas Analysis

The production of BAs from all food-borne pathogens in this work was monitored using tyrosine decarboxylase broth (TDB) suggested by Klausen and Huss (1987). The extraction process and derivatisation of BAs were performed in accordance with the method of Kuley and Ozogul (2011). The mobile phase contained acetonitrile (Sigma 439134, Steinheim, Germany) and grade water for the amine analyses. A high-performance liquid chromatography (HPLC, Shimadzu, Kyoto, Japan) was used to detect BAs. ODS Hypersil (5µ, 250x6 mm, Phenomenex, UK) was used as column.

Monitoring bacterial growth in TDB

Estimation of total viable counts in TDB was made in triplicate. Plate count agar (Fluka 70152; Steinheim, Switzerland) was used to growth of bacteria. Spread plates with appropriate dilution of 0.1 ml were incubated for 2 days at 30°C.

Statistical Analysis

Mean and standard deviation of three replicates were measured. The significance of differences (p<0.05) was determined using Oneway ANOVA with SPSS 15.0 version (SPSS Inc., USA).

Result and Discussion Bacterial growth in TDB

Bacterial load in TDB in the existence or absence of propolis extracts was shown in Table 1. Bacterial loads in control groups were in range from 8.41 log cfu/ml for S. Paratyphi A to 8.95 log cfu/ml for Y. enterocolitica. Significant differences in bacterial load apart from S. aureus were observed between control and propolis treated groups (p<0.05). By contrast, propolis extracts exhibited different extents of inhibitory effects against S. aureus, depending on concentration, collecting area and time (Lu et al., 2005; Apaydın and Gümüş, 2018). Presence of water or ethanolic propolis extracts in TDB resulted in lower bacterial growth (p<0.05), although extracts statistically did not affect growth of S. aureus. The highest inhibitory effects were observed against Gram-negative S. Paratyphi A (>1.9 log reduction), Y. enterocolitica (>1.2 log reduction) and C. jejuni growth (>1 log reduction). Propolis acted against both Gram-positive and Gram-negative bacteria.

The antimicrobial action of propolis is related to its natural ingredients and is different in individual countries (Przybyłek and Karpiński, 2019). However, the propolis was also reported to have better action against Gram-positive bacteria than Gram-negative (Kim and Chung, 2011; Pobiega et al., 2019). Among Gram-positive bacteria, the highest growth inhibition of propolis extracts was found against E. faecalis, with about 0.7 log reduction. The effects of ethanolic and aqueous propolis extracts on bacterial growth were statistically similar except for L. monocytogenes. However, Al-Ani et al. (2018) found that aqueous extract of propolis exerted poor bactericidal action against Gram-negative bacteria. Similarly, ethanolic propolis extracts were more effective than that of water extract on growth inhibition of L. monocytogenes in TDB (p < 0.05). Ethanol extract of propolis exhibited strong antilisterial activity (Pobiega et al., 2019; Temiz et al., 2011). The antibacterial action of propolis is as a consequence of the direct action on the microorganism and encouragement of the immune system causing in initiation of natural defences of the organism (Sforcin and Bankova, 2011; Przybyłek and Karpiński, 2019).

Biogenic amine production by bacteria

Figure 1 shows tyramine accumulation by food-borne pathogens. Tyramine production was the lowest with *S*. Paratyphi A (1.94 mg/L) and highest with *E. faecalis* (254.93 mg/L). *Enterococcus* spp. are important tyramine producer in fermented foods and able to yield TYR more than 520 mg/L (Connil et al., 2002; Özogul and Özogul, 2007; de Palencia et al., 2011). Tyramine accumulation was the weakest (6.42 mg/L) with *K. pneumoniae* among food-borne pathogens tested (Özogul et al., 2015). In the present study, *K. pneumoniae* accumulated tyramine at a moderate level (29.53 mg/L).

Presence of propolis ethanolic extracts in TDB led to significantly fewer tyramine production by Gram-positive *L. monocytogenes, E. faecalis, S. aureus* and Gram-negative *C. jejuni* (p<0.05). However, aqueous extracts of propolis caused considerably higher tyramine formation by all of food-borne pathogens, mainly Gram negative-bacteria. The highest stimulating effect of aqueous propolis extracts was found for S. Paratyphi A, with 146-fold higher tyramine production, which was not consistent with result of bacterial load in TDB. Tyramine production by K. pneumonia and Y. enterocolitica were also 11 and 13 fold higher with propolis aqueous extracts. The presence of 6 mg tyramine in one or two usual servings of food is thought to be sufficient to cause a mild adverse event while 10-25 mg will produce a severe adverse event in those using MAOI drugs (Da Prada et al., 1988). A limit of 200-800 mg in one or two usual servings has been proposed for tyramine in foods (Da Prada et al., 1988; Marcobal et al., 2012). Food borne-pathogens produced tyramine between 4.93 (Y. enterocolitica) and 37.64 mg/L (L. monocytogenes) in the presence of ethanolic propolis extract.

Table 1. Bacterial growth in tyrosine decarboxylase broth with or without propolis extracts (log cfu/mL)

	Control	Ethanolic extracts of propolis	Water extracts of propolis
Gram-positive bacteria			
L. monocytogenes	8.69±0.01a	8.51±0.02c	8.62±0.01b
E. faecalis	8.56±0.01a	7.88±0.10b	7.77±0.01b
S. aureus	8.55±0.05a	8.51±0.00a	8.50±0.00a
Gram-negative bacteria			
S. Parathyphi A	8.41±0.22a	6.51±0.16b	5.92±0.21b
K. pneumoniae	8.58±0.00a	7.83±0.08b	7.70±0.09b
Y. enterocolitica	8.95±0.08a	7.68±0.03b	7.72±0.06b
C. jejuni	8.90±0.05a	7.68±0.07b	7.85±0.11b

*Data are stated as mean value of three samples, Mean value±Standard deviation.

^{a-c} Show statistically significant differences (P < 0.05) between control and treated group in a column.



Figure 1. Tyramine accumulation by food borne pathogens in the absence or existence of propolis extracts. PE: group treated with ethanolic extract of propolis, PW: group treated with aqueous extract of propolis. ^{a-c} Show statistically significant differences (P < 0.05) between control and treated group

Table 2 and 3 illustrate ammonia and BAs production by Gram-positive and -negative food-borne pathogen in the absence or presence of propolis extracts, respectively. Ammonia production was in range from 167.63 mg/L by *C. jejuni* to 469.57 mg/L by *K. pneumoniae*. The highest ammonia accumulation was reported for *K. pneumoniae* and *S. aureus* (470-525 mg/L) in TDB (Kuley and Özogul, 2011), which was consistent with current results. Both extracts of propolis were significantly effective on reducing ammonia production by bacteria (p<0.05). Ethanolic extracts of propolis was more effective on reducing ammonia production by *E. faecalis* (2 fold-lower) and *S. aureus* (3-fold lower) than that of aqueous extracts (p<0.05), although both extracts of propolis showed statistically similar inhibitory effect on ammonia production by most of the bacteria.

Food-borne bacteria produced all amine tested apart from tryptamine. Tyramine, dopamine, agmatine and spermine were main amines produced in TDB, which was in agreement with result of Ozogul et al. (2015). Putrescine production was the highest with Y. enterocolitica (35.75 mg/L) and C. jejuni (32.50 mg/L), whilst C. jejuni (40.32 mg/L) and L. monocytogenes were main cadaverine producer. S. aureus and S. Paratyphi A produced considerably higher concentrations of putrescine than other food-borne pathogens (De las Rivas et al., 2006). In the current study, S. aureus and S. Paratyphi A produced putrescine at the level of 15.29 and 2.70 mg/L, respectively. Putrescine and cadaverine production by L. monocytogenes and C. jejuni was significantly inhibited by both propolis extracts. Moreover, presence of ethanolic extracts generally led to considerably lower putrescine and cadaverine production, although aqueous extracts of propolis mostly induced higher putrescine and cadaverine accumulation in TDB broth. Spermidine production by bacteria was above 4 mg/L and generally suppressed by both extracts. Spermine was produced at the highest level by L. monocytogenes and E. faecalis (about 60 mg/L). Although spermine production by L. monocytogenes and Y. enterocolitica considerably suppressed by presence of aqueous or ethanolic extracts of propolis, aqueous extracts of propolis resulted in higher spermine production by Gram-positive S. aureus and Gram-negative C. jejuni and K. pneumoniae.

Histamine is known as the causative agent of histamine intoxication and causes diarrhea, headache, rhinoconjunctival symptoms and other reactions in immunocompromised patients (Maintz and Novak, 2007; Comas-Basté et al., 2019). The US Food and Drug Administration (1995) recommended an upper limit of histamine to 5 mg/100 g (50 ppm) in fish (Al-Bulushi et al., 2009), whilst the European Commission (Commission Regulation EC No. 1441/2007, 2007) has suggested that the mean content of histamine in fish should not be above 10 mg/100g. Histamine produced lower than 1.3 mg/L by all food-borne pathogens. Ethanolic extracts of propolis was generally led to lower histamine production by bacteria. However, inhibitory effect of aqueous extract of propolis on histamine formation was just detected for Y. enterocolitica and C. jejuni, whilst it stimulated histamine production by E. faecalis, S. aureus and K. pneumoniae. The highest histamine production (3.24 mg/L) was found for E. faecalis in the existence of aqueous extracts of propolis. Serotonin production by bacteria was <6 mg/L in TDB. Serotonin accumulation by the most of bacteria was also inhibited by ethanolic propolis extract. Suppression effects of aqueous extract on serotonin production were observed for *L. monocytogenes*, *S. aureus* and *C. jejuni*.

TMA production by bacteria was between 1.25 and 50.34 mg/L by *S*. Paratyphi A and *K. pneumoniae*, respectively. Apart from *K. pneumoniae* and *Y. enterocolitica*, stimulatory effect of propolis extracts on TMA production was found. *K. pneumoniae* and *S*. Paratyphi A had good ability to produce dopamine in TDB, with corresponding value of 554.84 and 523.52 mg/L, whilst Gram-positive bacteria produced dopamine below 145 mg/L.

Propolis ethanolic extract had a significant effect on suppression of dopamine production by Gram-negative bacteria mainly C. jejuni, but ineffective against Gram-positive bacteria apart from L. monocytogenes. However, aqueous extract of propolis increased dopamine production of all Gram-positive bacteria tested, whilst it did not affect dopamine formation by C. jejuni and K. pneumoniae. Agmatine accumulation was the uppermost by C. jejuni and K. pneumoniae, with corresponding value of 95.50 and 90.81 mg/L. Both propolis extracts resulted in lower agmatine production by these bacteria (p<0.05), whereas there were no substantial differences in agmatine production by these bacteria between control and aqueous extracts groups. However, agmatine production by Gram-positive bacteria increased with aqueous extracts of propolis (p<0.05). The antimicrobial mechanisms of propolis are multiple and complex, being determined by the synergistic effects of phenolic compounds and other biologically active components (Hazem et al., 2017). Increase in most of BAs in the presence of aqueous extracts of propolis may be due to the fact that the basic biologically active constituents of propolis are hardly soluble in water (Kubiliene et al., 2015). Other reasons for the increase in BAs may be due to the presence of other synergistic conditions, such as changes in water activity and pH. Therefore, more detailed studies are needed to determine this effect.

Conclusions

Propolis extracts showed good antimicrobial activity against food-borne pathogens apart from *S. aureus* in TDB. The highest growth inhibitory activity of propolis extracts was observed for Gram-negative *S.* Paratyphi A, *C. jejuni* and *Y. enterocolitica*. Bacterial growth did not generally associate well with BAs production. The influence of propolis on BAs formation varied according to the type of extracts, specific BAs and bacterial strains, although ammonia production by bacteria was suppressed in the existence of propolis extract. The study results revealed that aqueous extract of propolis showed synergistic effects on the most of BAs production by bacteria mainly tyramine. In conclusion, it has been suggested that the use of the ethanolic propolis extract in food products may be more suitable than the aqueous extract of propolis.

-{}

Int J Agric Environ Food Sci 3(4): 265-271 (2019)

Table 2a Ammonia and BAs accumulation b	v Gram-nositiv	e food horne nath	ogen in the absence or	presence of propolis extracts (mg/L)
Table 2a. 7 minorita and D/15 accumulation b	y Orann-positiv	e ioou oome pau	logen in the absence of	presence of propons extracts (mg/L).

				-		
	AMN	PUT	CAD	SPD	PHEN	SPN
	206.42±8.17a	3.99±0.10a	33.27±1.07a	7.53±0.04a	2.73±0.12b	62.21±4.15a
LM	123.08±7.59b	0.50±0.00c	5.17±0.08c	0.00±0.00b	0.55±0.07c	24.68±1.16c
	129.44±5.23b	0.87±0.02b	19.60±0.80b	0.00±0.00b	24.28±0.95a	45.99±3.19b
	213.70±3.80a	3.45±0.28b	7.38±0.86b	21.25±0.43a	8.62±0.63b	61.23±5.07a
EF	89.13±2.90c	0.00±0.00c	6.25±0.08b	13.95±0.15b	0.92±0.03c	53.91±4.85ab
	115.92±4.99b	12.42±0.12a	37.42±0.44a	0.00±0.00c	32.47±0.58a	44.50±0.91c
	274.58±11.76a	15.29±1.31b	10.15±0.03b	4.16±0.13a	0.93±0.03c	4.82±0.14b
SA	88.92±5.35c	7.45±0.12c	2.42±0.08c	2.01±0.00b	2.23±0.05b	5.19±0.44b
	135.25±13.35b	26.47±0.36a	17.52±1.26a	3.86±0.21a	5.38±0.07a	27.07±0.06a
di TD	1 1	0.1 1 1	1 . 0 . 1 1	4 1		

*Data are expressed as mean value of three samples, Mean value±Standard deviation.

 $^{a\text{-c}}$ Show statistically significant differences (P \leq 0.05) between control and treated group in a row.

LM: *Listeria monocytogenes*, EF: *Enterococcus faecalis*, SA: *Staphylococcus aureus*, C: control group without propolis extract addition, PE: group treated with ethanolic extract of propolis, PW: group treated with aqueous extract of propolis. AMN, ammonia; PUT, putrescine; CAD, cadaverine; SPD, spermidine; PHEN, 2-phenylethyl amine; SPN, spermine

Table 2b. Ammonia and BAs accumulation by G	Fram-positive food borne	pathogen in the absence or	presence of propolis extracts (mg/L).
---	--------------------------	----------------------------	---------------------------------------

	HIS	SER	TMA	DOP	AGM	Groups
	1.29±0.04a	4.06±0.16a	1.88±0.02c	70.50±3.69c	39.79±2.75c	С
LM	0.28±0.00b	1.85±0.04c	3.44±0.06b	128.82±6.92b	60.44±0.64b	PE
	1.28±0.03a	3.38±0.05b	5.64±0.84a	317.28±14.66a	76.34±7.14a	PW
	0.89±0.05b	1.56±0.04b	8.28±0.77c	62.35±1.77b	25.15±1.13c	С
EF	0.42±0.01c	1.42±0.08b	21.99±0.16b	64.17±3.77b	54.33±1.94b	PE
	3.24±0.06a	3.72±0.20a	27.76±1.60a	155.24±1.94a	64.54±1.31a	PW
	0 38±0 00b	3 25±0 13a	3 06±0 16c	144 87±7 37b	15 79±0 86b	С
SA	0.13±0.01b	1.08±0.01c	3.75±0.02b	129.87±7.88b	16.74±0.77b	PE
	2.43±0.23a	2.42±0.14b	13.20±0.27a	459.91±29.80a	64.39±2.91a	PW

*Data are expressed as mean value of three samples, Mean value±Standard deviation.

 $^{a-c}$ Show statistically significant differences (P < 0.05) between control and treated group in a row.

LM: *Listeria monocytogenes*, EF: *Enterococcus faecalis*, SA: *Staphylococcus aureus*, C: control group without propolis extract addition, PE: group treated with ethanolic extract of propolis, PW: group treated with aqueous extract of propolis. HIS: histamine, SER, serotonin; TMA, trimethylamine; DOP, dopamine, AGM, agmatine

Table 3a. Ammonia and BAs accumulation by Gram-negative food borne pathogen in the absence or presence of propolis extracts (mg/L)

	AMN	PUT	CAD	SPD	PHEN	SPN
	272.12±21.91a	35.75±0.07b	17.05±0.10a	19.63±0.80a	10.21±0.23b	55.85±1.43a
YE	118.28±8.15b	1.91±0.13c	15.21±1.50a	8.86±0.46b	0.00±0.00c	27.70±0.02c
	82.75±3.28b	60.20±2.78a	14.20±1.35a	0.00±0.00c	11.45±0.48a	36.53±0.15b
	167.63±11.25a	32.50±2.76a	40.32±1.89a	10.27±0.29a	0.72±0.05b	35.35±2.31b
CJ	97.37±4.66b	0.00±0.00c	7.39±0.17c	0.00±0.00c	0.54±0.06b	35.04±0.27b
	98.08±6.87b	25.97±1.37b	33.73±2.36b	1.26±0.01b	1.11±0.10a	67.37±2.65a
	469.57±24.54a	1.36±0.14b	4.85±0.49b	31.23±2.13a	0.39±0.01c	32.36±2.46b
KP	94.62±6.89b	0.35±0.03b	3.29±0.02b	0.00±0.00b	0.90±0.13b	30.52±2.45b
	107.91±1.24b	61.94±5.38a	35.43±2.26a	2.16±0.13b	2.48±0.16a	48.01±3.92a
	268.48±23.57a	2.70±0.18b	24.57±1.70a	18.39±1.07a	0.78±0.00b	53.30±2.78a
SP	102.63±7.72b	0.69±0.02c	13.69±0.15c	17.55±0.07a	0.00±0.00b	31.89±1.27b
	143.94±12.71b	26.71±0.33a	19.18±1.80b	4.57±0.00b	16.82±1.29a	50.91±3.90a

*Data are expressed as mean value of three samples, Mean value±Standard deviation.

 $^{a\text{-c}}$ Show statistically significant differences (P \leq 0.05) between control and treated group in a row.

YE: Yersinia enterocolitica, CJ: Campylobacter jejuni, KP: Klebsiella pneumoniae, SP: Salmonella Paratyphi A, C: control group without propolis extract addition, PE: group treated with ethanolic extract of propolis, PW: group treated with aqueous extract of propolis. AMN, ammonia; PUT, putrescine; CAD, cadaverine; SPD, spermidine; PHEN, 2-phenylethyl amine; SPN, spermine

Aykut Burgut

-()

DOI: https://dx.doi.org/10.31015/jaefs.2019.4.11

Table 3b. Ammonia and BAs accumulation by	Gram-negative food borne pathogen in the absence of	presence of propolis extracts (mg/L)
ruore borr mininerina ana brie accamatanation e	Grain negative root office pathogen in the abbenee of	

	HIS	SER	ТМА	DOP	AGM	Groups
	1115	SER	1 101/1	DOI	AGM	Groups
	0.99±0.01a	2.66±0.27b	12.27±0.55b	263.42±15.39b	74.88±1.52b	С
YE	0.63±0.05c	1.10±0.08c	3.84±0.22c	125.20±7.35c	85.09±5.02ab	PE
	0.78±0.04b	3.93±0.32a	16.77±1.05a	308.47±16.99a	86.22±2.43a	PW
	1.18±0.03a	5.79±0.28a	5.39±0.19b	393.80±14.95a	95.50±8.19a	С
CJ	0.47±0.01c	0.73±0.03b	24.97±0.01a	0.00±0.00c	48.31±3.24b	PE
	0.86±±0.07b	1.02±0.04b	6.12±0.50b	270.91±3.14b	85.92±0.73a	PW
	0.38±0.00b	2.48±0.02b	50.34±0.81a	554.84±37.36a	90.81±8.81a	С
KP	0.42±0.02b	1.10±0.00c	13.40±1.27c	205.63±7.97b	64.23±3.84b	PE
	0.84±0.06a	3.71±0.46a	35.32±0.36b	630.83±29.43a	93.57±2.62a	PW
	0.70±0.03a	2.24±0.16b	1.25±0.00c	523.52±13.94a	25.57±1.00b	С
SP	0.31±0.01b	0.77±0.08c	3.15±0.14b	296.97±2.15b	36.07±0.37b	PE
	0.77±0.02a	4.95±0.29a	15.25±0.26a	521.92±3.47a	131.67±6.35a	PW

*Data are expressed as mean value of three samples, Mean value±Standard deviation.

^{a-c} Show statistically significant differences ($P \le 0.05$) between control and treated group in a row.

YE: Yersinia enterocolitica, CJ: Campylobacter jejuni, KP: Klebsiella pneumoniae, SP: Salmonella Paratyphi A, C: control group without propolis extract addition, PE: group treated with ethanolic extract of propolis, PW: group treated with aqueous extract of propolis. HIS: histamine, SER, serotonin; TMA, trimethylamine; DOP, dopamine, AGM, agmatine

References

- Afrouzan, H., Tahghighi, A., Zakeri, S. and Es-haghi, A. (2018). Chemical Composition and Antimicrobial Activities of Iranian Propolis. Iranian Biomedical Journal, 22, 1, 50-65 [CrossRef]
- Al-Ani, I., Zimmermann, S., Reichling, J. and Wink, M. (2018). Antimicrobial activities of European propolis collected from various geographic origins alone and in combination with antibiotics. Medicines, 5, 1, 2. [CrossRef]
- Al Bulushi, I., Poole, S., Deeth, H.C., Dykes, G.A. (2009). Biogenic amines in fish: Roles in intoxication, spoilage, and nitrosamine formation. Critical Reviews in Food Science and Nutrition, 49, 369–377.
- Apaydin, H. and Gümüş, T. (2018). Inhibitory effect of propolis (bee gum) against *Staphylococcus aureus* bacteria isolated from instant soups. Journal of Tekirdag Agricultural Faculty, 15, 1, 67-75.
- Camino Feltes, M. M., Arisseto-Bragotto, A. P. and Block, J. M. (2017). Food quality, food-borne diseases, and food safety in the Brazilian food industry. Food Quality and Safety, 1, 1, 13-27. [CrossRef]
- Casquete, R., Castro, S. M., Jácome, S. and Teixeira, P. (2016). Antimicrobial activity of ethanolic extract of propolis in "Alheira", a fermented meat sausage. Cogent Food and Agriculture, 2, 1, 1125773. [CrossRef]
- Comas-Basté, O., Latorre-Moratalla, M. L., Sánchez-Pérez, S., Veciana-Nogués, M. T. and del Carmen Vidal-Carou, M. (2019). Histamine and other biogenic amines in food. From scombroid poisoning to histamine intolerance. In Biogenic Amines. IntechOpen. [CrossRef]
- Commission Regulation (EC) (2007). No: 1441/2007 Amending regulation (EC) No 2073/2005 on microbiological criteria for foodstuffs. Official Journal of European Union L, 322, 12–29.
- Connil, N., Breton, Y. L., Dousset, X., Auffray, Y., Rincé, A. and Préevost, H. (2002). Identification of the *Enterococcus faecalis* tyrosine decarboxylase operon involved

in tyramine production. Applied and Environtal Microbiology, 68, 3537–3544. [CrossRef]

- Da Prada, M., Zurcher, G. and Wuthrich, I.(1988). On tyramine, food, beverages: the reversible MAO inhibitor monoclobemide. Journal of Neural Transmission, 26, 31–36.
- De Figueiredo, S.M., Binda, N.S., Almeida, B.D.M., Lemos Abreu, S.R., de Abreu, J.A.S., Pastore G.M., Sato H.H., Toreti V.C., Tapia, E.V. and Park, Y.K. (2015). Green propolis: Thirteen constituents of polar extract and total flavonoids evaluated during six years through RP-HPLC. Current Drug Discovery Technologies, 12, 229–239.
- De las Rivas, B., Marcobal, A., Carrascosa, A. and Munoz, R. (2006). PCR detection offood bacteria producing the biogenic amines histamine, tyramine, putrescineand cadaverine. Journal of Food Protection, 69, 2509–2514. [CrossRef]
- De Palencia, P. F., Fernández, M., Mohedano, M. L., Ladero, V., Quevedo, C., Alvarez, M. A. and López, P. (2011). Role of tyramine synthesis by food-borne Enterococcus durans in adaptation to the gastrointestinal tract environment. Applied and Environmental Microbiology, 77, 2, 699-702. [CrossRef]
- Fernández, M., Linares, D. M., del Río, B., Ladero, V. and Alvarez, M. A. (2007). HPLC quantification of biogenic amines in cheeses: correlation with PCR-detection of tyramine-producing microorganisms. Journal of Dairy Research, 74,3, 276-282. [CrossRef]
- Gram, L. and Dalgaard, P. (2002). Fish spoilage bacteria-problems and solutions. Current Opinion in Biotechnology, 13, 262–266. [CrossRef]
- Hazem, A., Popescu, C.V., Crisan, J., Popa, M., Chifiriuc, M., Pircalabioru, G.G. and Lupuliasa, D. (2017). Antibacterial efficiency of five propolis extracts on planktonic and adherent microbial strains. Farmacia, 65, 5, 813-818.
- Karovičová, J. and Kohajdová, Z. (2005). Biogenic amines in

Aykut Burgut

-{}

food. Chemical Papers, 59, 1, 70-79.

- Kim, Y. H. and Chung, H. J. (2011). The effects of Korean propolis against foodborne pathogens and transmission electron microscopic examination. New Biotechnology, 28, 6, 713-718. [CrossRef]
- Klausen, N.K. and Huss, H.H. (1987). A rapid method for detection of histamine-producing bacteria. International Journal of Food Microbiology, 5, 137-146.
- Kubiliene, L., Laugaliene, V., Pavilonis, A., Maruska, A., Majiene, D., Barcauskaite, K. and Savickas, A. (2015). Alternative preparation of propolis extracts: comparison of their composition and biological activities. BMC Complementary and Alternative Medicine, 15, 156, 1-7. [CrossRef]
- Kuley, E. and Özogul, F. (2011). Synergistic and antagonistic effect of lactic acid bacteria on tyramine production by food-borne pathogenic bacteria in tyrosine decarboxylase broth. Food Chemistry, 127, 3, 1163-1168. [Cross-Ref
- Li, L., Wen, X., Wen, Z., Chen, S., Wang, L. and Wei, X. (2018). Evaluation of the biogenic amines formation and degradation abilities of Lactobacillus curvatus from Chinese bacon. Frontiers in Microbiology, 9, 1015, 1-9. [CrossRef]
- Liu, Y., Cao, Y., Wang, T., Dong, Q., Li, J. and Niu, C. (2019). Detection of 12 common food-borne bacterial pathogens by TaqMan real-time PCR using a single set of reaction conditions. Frontiers in Microbiology, 10, 222, 1-9. [CrossRef]
- Lorenzo, J. M., Martínez, S., Franco, I. and Carballo, J. (2007). Biogenic amine content during the manufacture of drycured lacón, a Spanish traditional meat product: Effect of some additives. Meat Science, 77, 2, 287-293. [CrossRef]
- Lu, L. C., Chen, Y. W. and Chou, C. C. (2005). Antibacterial activity of propolis against Staphylococcus aureus. International Journal of Food Microbiology, 102, 2, 213-220. [CrossRef]
- Maintz, L. and Novak, N. (2007). Histamine and histamine intolerance. The American Journal of Clinical Nutrition 85, 1185–1196. [CrossRef]
- Majiene, D., Trumbeckaite, S., Pavilonis, A., Savickas, A. and Martirosyan, D. M. (2007). Antifungal and antibacterial activity of propolis. Current Nutrition and Food Science, 3, 4, 304-308.
- Marcobal, A., De Las Rivas, B., Landete, J. M., Tabera, L. and Muñoz, R. (2012). Tyramine and phenylethylamine biosynthesis by food bacteria. Critical Reviews in Food Science and Nutrition, 52, 5, 448-467. [CrossRef]
- Nedji, N. and Loucif-Ayad, W. (2014). Antimicrobial activity of Algerian propolis in foodborne pathogens and its quantitative chemical composition. Asian Pacific Journal of Tropical Disease, 4, 6, 433-437. [CrossRef]
- Özogul, F. and Özogul, Y. (2007). The ability of biogenic amines and ammonia production by single bacterial cultures. European Food Research and Technology, 225, 385-394. [CrossRef]

- Özogul, F., Kaçar, Ç. and Kuley, E. (2015). The impact of carvacrol on ammonia and biogenic amine production by common foodborne pathogens. Journal of Food Science, 80, 12, M2899-M2903. [CrossRef]
- Pobiega, K., Kraśniewska, K., Przybył, J. L., Bączek, K., Żubernik, J., Witrowa-Rajchert, D. and Gniewosz, M. (2019). Growth biocontrol of foodborne pathogens and spoilage microorganisms of food by polish propolis extracts. Molecules, 24, 16, 2965. [CrossRef]
- Przybyłek, I. and Karpiński, T. M. (2019). Antibacterial properties of propolis. Molecules, 24, 11, 1-17. [CrossRef]
- Satoshi, M., Yoshikazu, I., Yukio, N., Shozo, O., Takashi, S., Yoko, A. and Yoshinori, N. (2005). Identification of caffeoylquinic acid derivatives from Brazilian propolis as constituents involved in induction of granulocytic differentiation of HL-60 cells. Bioorganic and Medicinal Chemistry, 13, 5814–5818. [CrossRef]
- Silla-Santos, M. H. (1996). Biogenic amines: their importance in foods. International Journal of Food Microbiology, 29, 2-3, 213-31. [CrossRef]
- Sforcin J.M. and Bankova V. (2011). Propolis: Is there a potential for the development of new drugs? Journal of Ethnopharmacology, 133, 253–260. [CrossRef]
- Shalaby, A.R. (1996). Significance of biogenic amines to food safety and human health. Food Research International, 29, 7, 675-690. [CrossRef]
- Temiz, A., Sener, A., Tüylü, A. Ö., Sorkun, K. and Salih, B. (2011). Antibacterial activity of bee propolis samples from different geographical regions of Turkey against two foodborne pathogens, Salmonella enteritidis and Listeria monocytogenes. Turkish Journal of Biology, 35, 4, 503-511. [CrossRef]
- Wendakoon, C.N. and Sakaguchi, M. (1995). Inhibition of amino acid decarboxylase activity of Enterobacter aerogenes by active components in spices. Journal of Food Protection, 58, 3, 280-283. [CrossRef]