

Biochemistry and antimicrobial activity (in vitro) of the orange (*Citrus sinensis*), brazilian peppertree, (*Schinus terebinthifolius, Raddi*) and melaleuca (*Melaleuca quinquenervia*) honey produced in S.E. Florida, USA.

Dr. Vetaley Stashenko; PhD; ND; RN; Mrs. Darina Stashenko

Human evolution can be defined from different points of view. One of them - as a struggle between a human organism and the microbial world for living niche in Nature.

Auspiciously for this audience we are familiar with the compound which can be nominated as a defender of *Homo sapiens* against the wide range of unfriendly organisms and compounds. This is the ordinary honey which was most likely one of the primary products which the human became familiar with in Nature.

In present work we have taken into consideration the established relationship between the chemical composition, biological and microbiological properties and the geographic and climatic factors, the present studies were conducted with the objective to provide for the first time the basic biochemical composition and microbiological characteristics of the main commercial honeys from SE Florida, USA - orange - *Citrus sinensis* (L.); **palmetto** - *Serenoa repens* (W. Bartram); brazilian peppertree - *Schinus terebinthifolius* Raddi; and melaleuca - *Melaleuca quinquenervia* (Cav.)

Orange honey

It is a thick (low moisture), very sweet (high fructose content) honey. Light amber to white, the lighter color and milder flavor coming in years when there is a large harvest and the honey is little contaminated by other nectars.

Strong, citrusy aroma. Primarily, the aroma is of middling concentration reminiscent of orange blossoms

Saw Palmetto Honey.

Primarily found in Florida, Saw palmetto honey is thick, and opaque with a moderate amount of honey crystals. It demonstrates a rich-yellow color and robust, slightly citrus and herbal flavors with woody overtones and a strong finish, with a thinner body than most honeys. Saw Palmetto is a rich yellow color, often considered the best in Florida.

All parts of the plant are known for its health properties.

Rheological properties (means \pm SD) of honey produced in SE Florida.

Year of production	Source of honey	Moisture, (% w/w)	Acidity, (meg kg ⁻¹)		pH (Units)	Ash content (% w/w)	Reducing sugars (%)
			free	total			
2007	O	16.5 \pm 0.12	23.5 \pm 0.98	26.1 \pm 0.98	3.44 \pm 0.01	0.08 \pm 0.017	74.12 \pm 0.32
	P	16.3 \pm 0.11	20.7 \pm 0.88	23.8 \pm 1.13	3.88 \pm 0.02	0.16 \pm 0.016	72.7 \pm 0.22
	BP	17.4 \pm 0.13	9.9 \pm 1.28	14.3 \pm 0.68	3.23 \pm 0.01	0.11 \pm 0.013	68.3 \pm 0.21
	M	18.2 \pm 0.10	19.2 \pm 0.88	22.5 \pm 1.23	3.01 \pm 0.01	0.22 \pm 0.017	69.6 \pm 0.21
2008	O	17.2 \pm 0.12	18.3 \pm 0.98	23.6 \pm 1.13	4.01 \pm 0.02	0.09 \pm 0.015	76.9 \pm 0.32
	P	16.1 \pm 0.12	32.3 \pm 0.78	35.1 \pm 0.68	3.79 \pm 0.01	0.18 \pm 0.017	74.6 \pm 0.22
	BP	17.0 \pm 0.11	12.6 \pm 1.28	16.2 \pm 0.98	3.11 \pm 0.01	0.18 \pm 0.015	67.6 \pm 0.23
	M	18.1 \pm 0.14	36.8 \pm 0.98	38.9 \pm 1.13	2.98 \pm 0.01	0.29 \pm 0.017	65.5 \pm 0.22
2009	O	15.3 \pm 0.12	22.6 \pm 0.98	25.5 \pm 0.89	3.79 \pm 0.02	0.12 \pm 0.013	79.3 \pm 0.32
	P	16.6 \pm 0.11	22.8 \pm 1.38	26.2 \pm 1.23	3.98 \pm 0.01	0.22 \pm 0.015	74.3 \pm 0.22
	BP	16.8 \pm 0.12	18.5 \pm 1.28	20.3 \pm 0.89	2.92 \pm 0.01	0.26 \pm 0.017	69.4 \pm 0.21
	M	18.2 \pm 0.14	14.7 \pm 0.88	16.9 \pm 0.89	3.12 \pm 0.01	0.31 \pm 0.017	68.5 \pm 0.21
2010	O	16.8 \pm 0.12	9.6 \pm 0.98	12.8 \pm 0.98	3.78 \pm 0.01	0.11 \pm 0.015	75.9 \pm 0.32
	P	16.3 \pm 0.11	34.8 \pm 0.88	37.2 \pm 1.23	4.16 \pm 0.02	0.17 \pm 0.017	74.7 \pm 0.32
	BP	17.5 \pm 0.12	11.6 \pm 0.78	13.8 \pm 0.89	2.95 \pm 0.01	0.22 \pm 0.017	64.6 \pm 0.22
	M	18.4 \pm 0.11	22.3 \pm 0.88	25.7 \pm 0.68	2.98 \pm 0.01	0.26 \pm 0.016	69.3 \pm 0.21
2011	O	14.9 \pm 0.14	11.5 \pm 0.8	14.4 \pm 0.89	3.89 \pm 0.01	0.16 \pm 0.013	78.2 \pm 0.32
	P	16.2 \pm 0.11	24.6 \pm 1.28	27.1 \pm 0.98	3.98 \pm 0.02	0.15 \pm 0.017	75.9 \pm 0.32

O – orange honey (*Citrus \times sinensis* (L.) Osbeck (pro sp.) [*maxima \times reticulata*]);
BP- brazilian peppertree honey (*Schinus terebinthifolius* Raddi);

P – saw palmetto honey (*Serenoa repens* (W. Bartram) Small)
M – melaleuca honey (*Melaleuca quinquenervia* (Cav.) S. T. Blake)

Minerals of the S.E. Florida honey's (mg/kg⁻¹.)

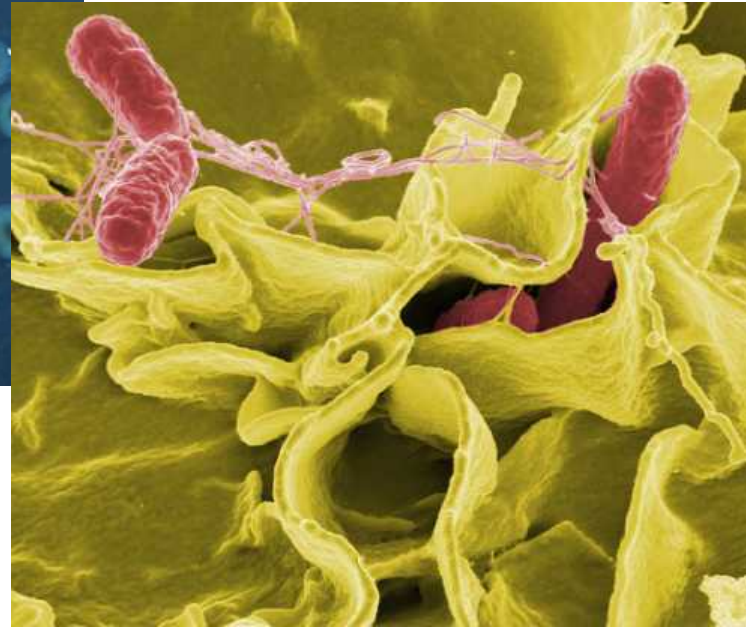
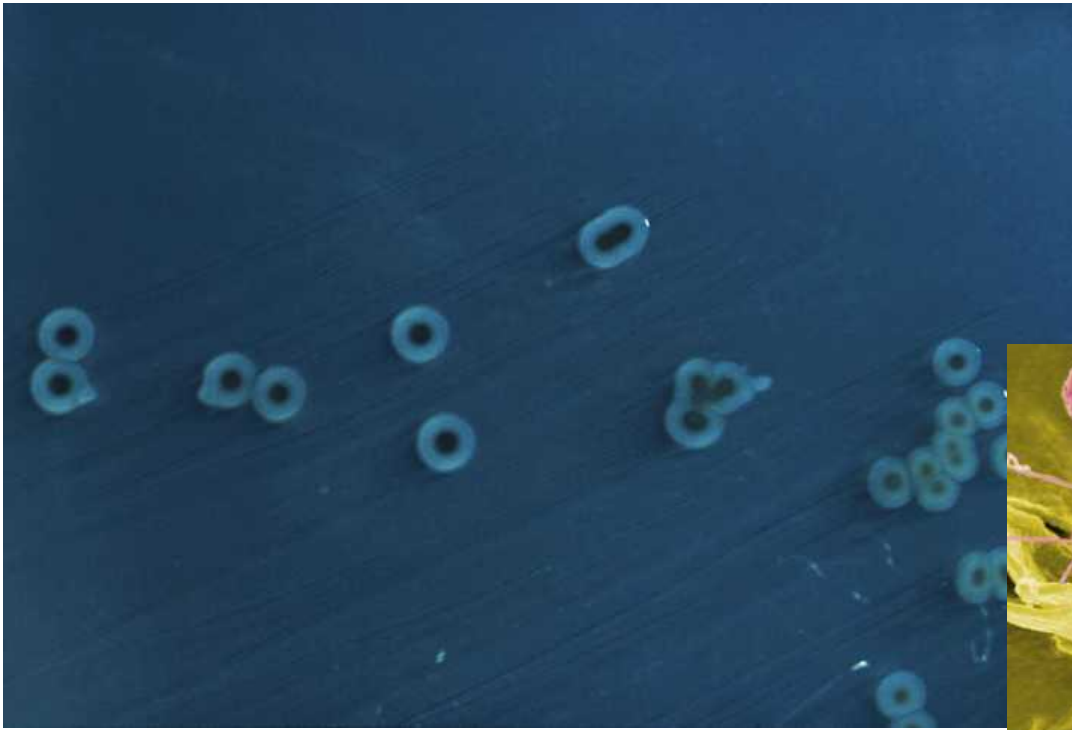
Minerals	Orange		Saw Palmetto		Brazilian peppertree		Melaleuca		S. d.
	Mean	Range	Mean	Range	Mean	Range	Mean	Range	
K	386.8	180-850	758.38	568-893	497.33	297-647	1456.2	1167-1758	239.9
Na	286.6	59-356	345.78	228-561	98.0	74-137	167.9	125-186	232.6
Ca	26.7	19-36.3	45.6	35.8-58	46.8	37-61.4	83.6	67-113	34.31
Mg	9.3	4.2-16.6	32.0	28-46.5	25.45	18-32.3	52.1	43.8-63	7.45
Al	9.3	5.6-23.8	13.64	7.4-16.8	14.24	8.3-16.8	21.4	17-28.8	17.71
Fe	17,4	11.4-34.1	3.27	1.1-5.8	6.8	4.6-8.5	9.6	6.7-14.5	5.3
Zn	6.98	3-11.4	4.24	2.5-6.8	3.76	2.1-5.9	2.11	1.6-3.7	3.67
Mn	0.11	0.06-0.3	3.67	1.2-6.7	0.423	0-0.56	0.84	0-1.12	0.44
Cu	3.14	1.4-8.4	0.35	0-0.56	0.568	0-0.67	4.96	2.79-6.7	1.407
Ba	0.285	0.1-0.67	5.95	3.4-7.8	0.234	0-0.45	0.13	0-0.25.	0.107
Ni	0.396	0.1-0.94	0.378	0-0.5.8	0.276	0-0.39	0.293	0-0.367	0.377
Pb	0.097	0-0.14	0.123	0-0.28	0.156	0-0.31	0.142	0-267	0.215
Cr	0.046	0-0.11	0.056	0-0.083	0.074	0-0.096	0.076	0-0.095	0.028
Co	0.125	0-0.234	0	0	0.005	0-0.008	0.096	0-0.126	0.026
As	0.001	0-0.003	0.002	0-0.04	0	0	0	0	0.032
Se	0.08	0-0.11	0.0456	0-0.067	0.032	0-0.057	0.09	0-0.11	0.02
Ag	0.001	0-0.002	0	0	0	0	0.001	0-0.002	0.022
Cd	0.003	0-0.008	0.003	0-0.006	0.001	0-0.002	0.087	0-0.12	0.018
Be	0.004	0-0.007	0	0	0	0	0	0	0.055
Au	0.001	0-0.002	0	0	0.001	0-0.002	0.001	0-0.003	0.046

Amino acid contents in honeys from S.E. Florida, USA.

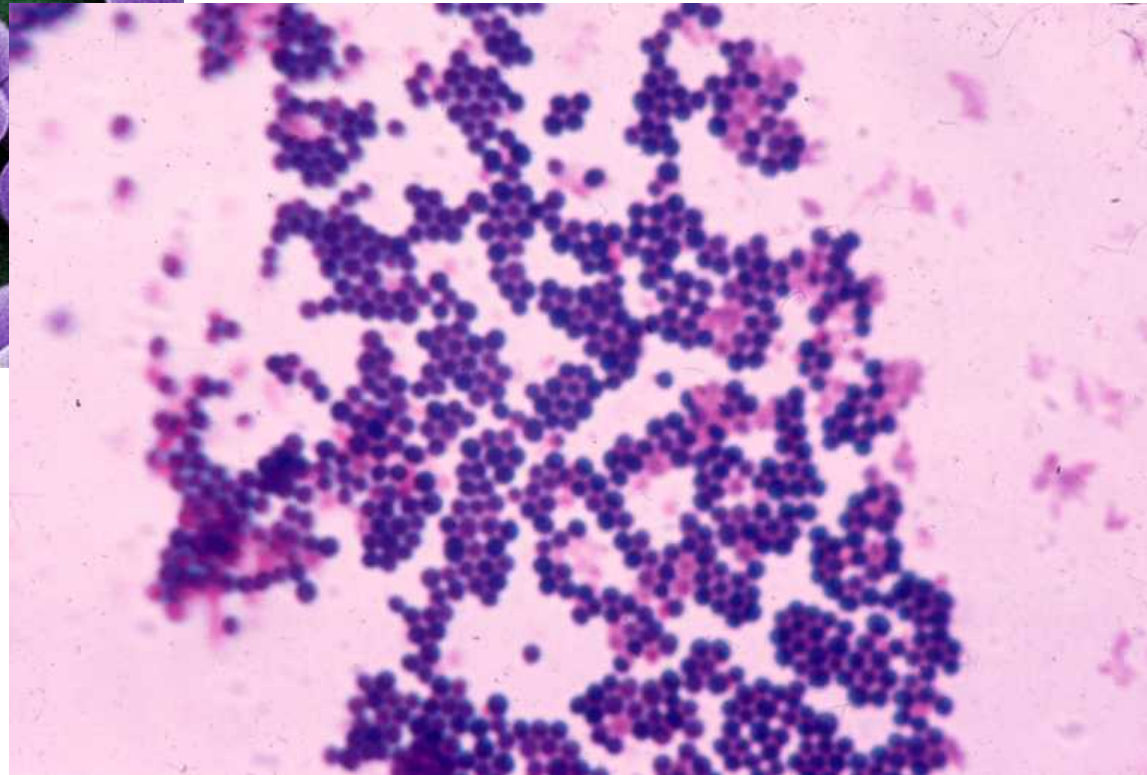
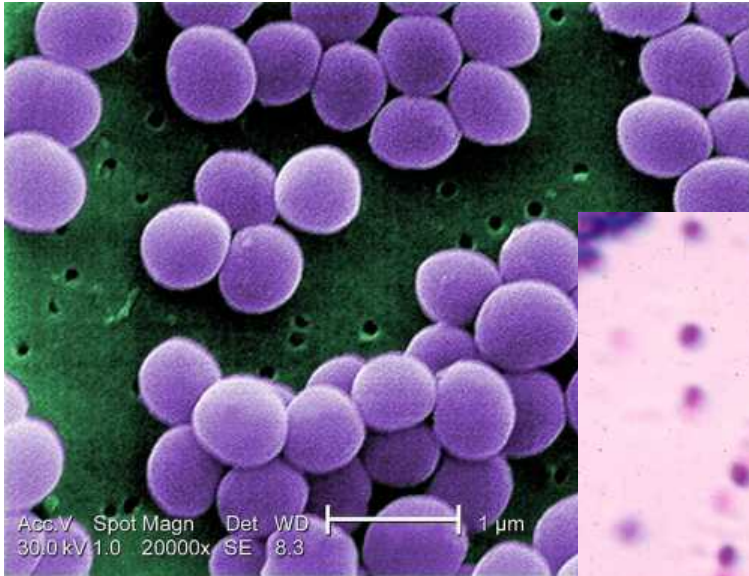
Amino acids	Orange (mg. kg ⁻¹)		Saw Palmetto (mg. kg ⁻¹)		Brazilian peppertree (mg. kg ⁻¹)		Melaleuca (mg. kg ⁻¹)		s. d.
	Mean	Range	Mean	Range	Mean	Range	Mean	Range	
Aspartic acid	11.53	4.8-19.16	19.3	5.3-22.41	20.16	11.8-38.5	22.41	15.9-39.98	11.8
Glutamic acid	8.3	4.5-16.86	12.7	5.65-18.63	12.68	5.68-26.46	19.3	4.5-38.3	2.2
Asparagine	6.9	4.1-11.86	15.8	5.8-22.14	3.23	0.63-8.62	28.57	11.7-43.1	5.5
Serine	5.8	3.2-8.96	9.58	6.2-14.5	15.77	8.24-23.6	20.3	12.4-32.6	10.9
Glutamine	18.5	12.7-26.4	7.56	5.6-12.4	11.8	8.56-14.5	30.5	22.4-38.4	9.7
Histidine	5.56	1.23-8.63	0.89	0-2.4	0.2	0-0.8	10.7	5.78-14.3	2.6
Glycine	2.86	0.3-6.64	4.14	0.78-6.87	2.4	0-3.65	6.56	4.6-8.89	1.9
Threonine	3.65	1.2-6.34	4.8	1.6-5.78	10.0	6.3-14.4	11.86	8.9-14.39	16.6
Alanine	8.67	3.56-12.5	16.7	9.3-21.4	13.05	8.65-17.4	22.8	18.7-27.4	15.8
Arginine	8.56	2.45-6.73	7.6	4.6-11.4	7.2	4.3-11.4	14.65	11.3-19.8	1.6
Cysteine	4.2	2.1-8.36	8.3	5.65-13.5	3.3	0-5.6	16.8	12.5-20.5	6.4
Valine	8.8	4.5-11.6	12.7	9.6-14.9	34.63	22.4-47.2	13.98	10.3-16.7	6.2
Methionine	2.6	0.2-8.86	4.0	1.5-7.2	6.19	4.56-8.38	3.27	2.34-4.86	1.5
Tryptophan	1.3	0.35-4.3	2.2	0.4-3.96	1.0	0-1.8	3.16	0-5.8	0.6
Phenylalanine	10.2	6.5-14.8	968.6	673-1238	10.39	5.87-14.8	25.56	19.4-28.8	4.6
Isoleucine	2.96	1.2-4.64	5.3	2.5-8.87	11.5	7.23-16.7	7.37	5.7-9.56	2.7
Leucine	2.83	1.1-5.7	3.5	2.13-5.3	0.7	0-1.5	8.39	5.9-13.6	4.59
Lysine	12.2	6.9-14.7	3.76	0.9-7.3	2.8	0-4.3	12.19	8.45-16.9	7.6
Proline	286.8	212.2-365	189.13	115-286	327.84	268-563	568.73	487-764	78.3

Sugar composition of South East Florida honey's (%)

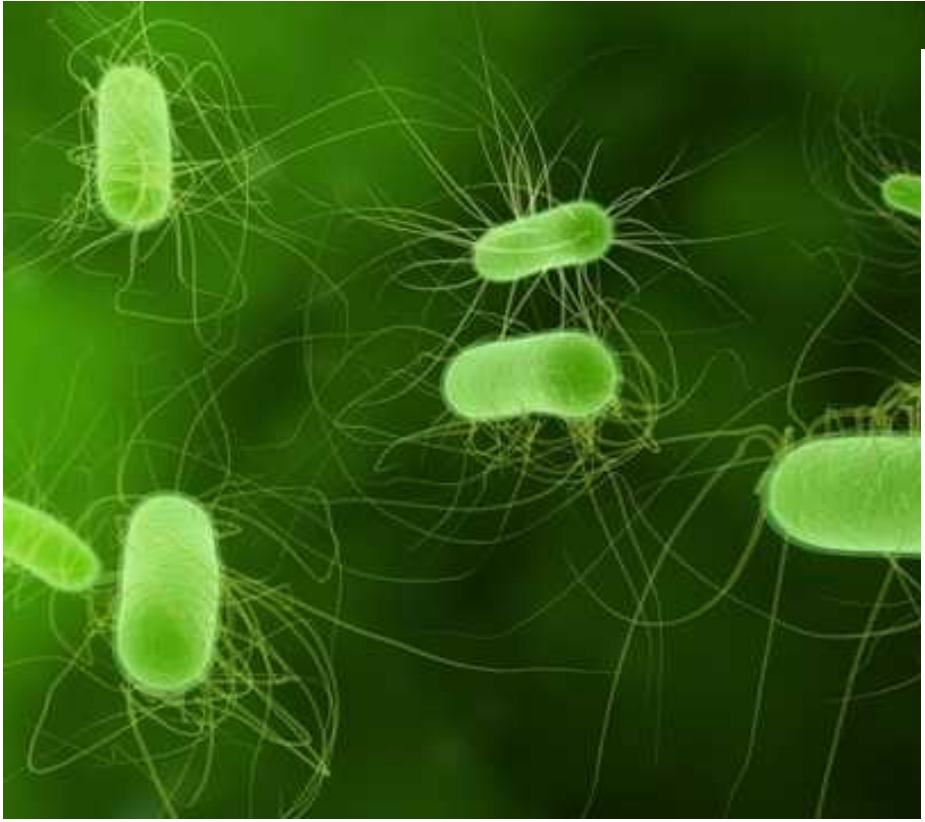
Parameter	Orange		Saw Palmetto		Brazilian peppertree		Melaleuca		s. d.
	Mean	Range	Mean	Range	Mean	Range	Mean	Range	
Glucose	31.4	29.3-34.8	30.8	29.2-35.1	36.8	31.4-38.5	35.6	31.6-37.4	1.72
Fructose	38.5	35.6-41.2	37.2	35.9-39.8	35.7	31.8-36.8	37.3	35.1-39.8	1.2
Sucrose	2.4	1.6-2.8	1.6	0.7-2.1	2.8	0.9-3.6	1.7	1.0-2.4	1.63
Trehalose	0.2	0-0.4	0.4	0-0.7	0.1	0-0.3	0.2	0-0.4	0.02
Maltulose	2.4	1.6-3.6	3.6	2.1-5.3	6.3	4.3-7.8	7.2	5.0-9.3	0.38
Maltose	0.4	0-0.6	0.3	0.1-0.5	0.8	0-1.1	1.6	1.0-2.1	2.15
Kojibiose	0.07	0-0.11	0.1	0-0.3	0.2	0-0.4	0.3	0-0.5	0.12
Gentiobiose	0.01	0-0.019	0.08	0-0.099	0.1	0-0.3	0.1	0-0.3	0.02
Isomaltose	0	0	0.1	0-0.19	0.2	0-0.3	0.5	0-0.7	0.15
Raffinose	0.01	0-0.019	0.06	0-0.079	0.09	0-0.11	0.1	0-0.3	0.05
Erlose	0	00	0	0	0.23	0-0.44	0.36	0-0.5	0.15
Melesitose	0	0	0	0	0	0	0.01	0-0.029	0.003
Nigerose	0	0	0	0	0.021	0-0.029	0.2	0-0.4	0.015
Turanose	0.02	0-0.029	0	0	0.12	0-0.3	0	0	0.018
Maltotriose	0	0	0.04	0-0.069	0	0	0.02	0-0.049	0.016
Panose	0	0	0	0	0.2	0-0.45	0	0	0.011
Centose	0.05	0-0.079	0	0	0	0	0	0	0.01
Isopanose	0	0	0.05	0-0.089	0	0	0.02	0-0.039	0.0018
1-Kestose	0.03	0-0.05	0	0	0.1	0-0.39	0.03	0-0.059	0.0028



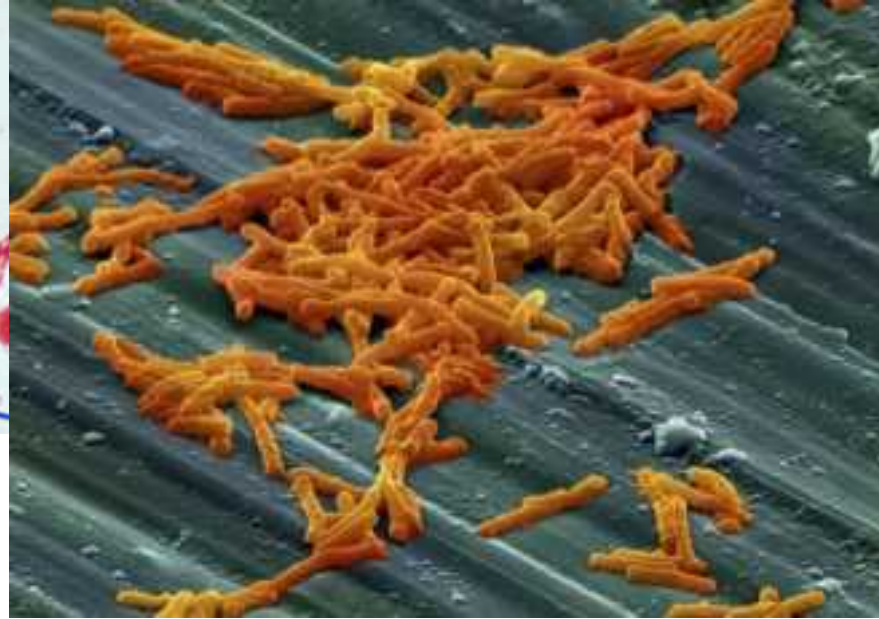
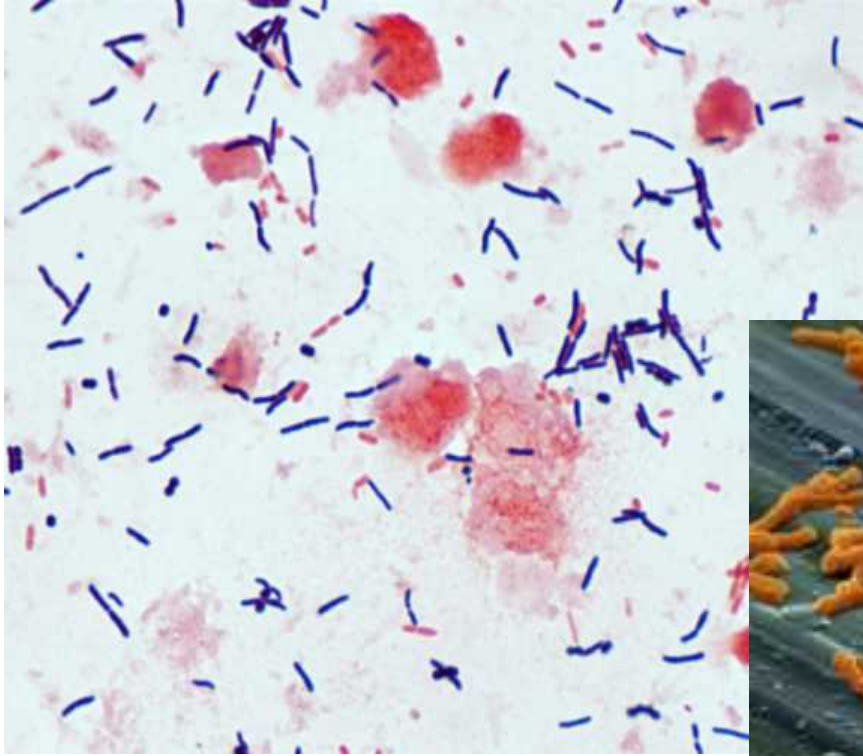
Salmonella enterica (formerly *Salmonella choleraesuis*) is a rod-shaped flagellated, facultative anaerobic, G- bacterium.



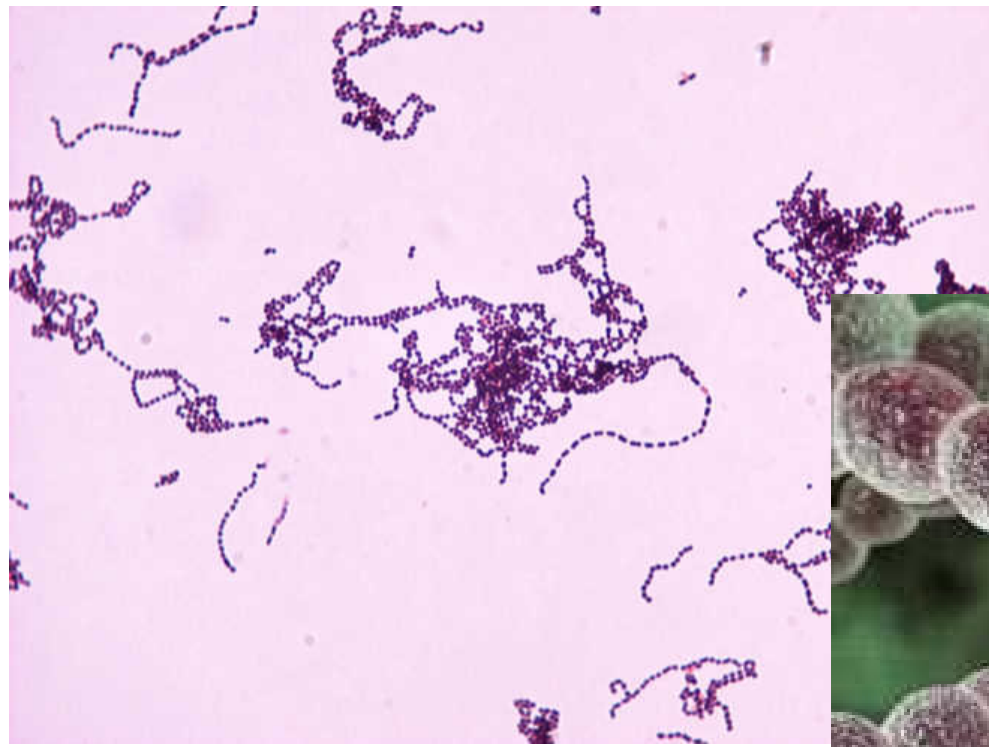
S. aureus is a facultative anaerobic G+ cocci bacterium, also known as "golden staph



Escherichia coli is a G-, facultative anaerobic, rod-shaped bacterium.



Clostridium difficile also known as "CDF/cdf", or "*C. diff*", is a G+, spore-forming bacterium that is best known for causing antibiotic associated diarrhea (AAD).



Streptococcus pyogenes is a spherical, G+ coccus that is the cause of group A streptococcal infections.

Inhibition effect of different concentration of orange (*Citrus ×sinensis* (L.) Osbeck (pro sp.) honey against selected microbial isolates. (diameter in mm./year of honey production)

Honey Concentration, (%)	Zone of inhibition							
	<i>S. aureus</i>		<i>E. coli</i>		<i>C. difficile</i>		<i>Sal. enterica</i>	
	Min.	Max.	Min,	Max.	Min.	Max	Min.	Max.
1	0.0	0.0 – 1.0	0.0 – 1.0	0.0-2.0	1	0.0	0.0	0.0
3	0.0	0.0 – 1.0	0.0 - 6	0.0 – 10.0	0.0	0.0	0.0	0.0
5	0.0	0.0 – 1.0	0.0 - 12	17/2007	0.0	5/2007	4/2007	14/2011
10	1.0-12.0	17/2011	8/2008	29/2008	0.0 -4	12/2011	7/2008	21/2011
25	8/2008	28/2008	9/2011	32/2008	7/2011	20/2011	5/2009	27/2011

S. aureus - *Staphylococcus aureus*; *E. coli* - *Escherichia coli*; *C. difficile* - *Clostridium difficile*; *Sal. enterica* - *Salmonella enterica*

Inhibition effect of different concentration of saw palmetto (*Serenoa repens* (W. Bartram) Small.) honey against selected microbial isolates. (diameter in mm./year of production)

Honey Concentration, (%)	Zone of inhibition							
	S. aureus		E. coli		C. difficile		Sal. enterica	
	Min.	Max.	Min,	Max.	Min.	Max	Min.	Max.
1	0.0	1	0.0	0	0.0	0	0.0	0
3	0.0	2	0.0	2	0.0	2	0.0	1
5	5	12	6	12	4	16	5	14
10	8	14	8	16/2011	8	18	9	19
25	9	18/2009	10/2007	18/2009	11	19	11	21

S. aureus - *Staphylococcus aureus*; *E. coli* - *Escherichia coli*; *C. difficile* - *Clostridium difficile*; *Sal. enterica* - *Salmonella enterica*

Inhibition effect of different concentration of **Brazilian Peppertree (*Schinus terebinthifolius* Raddi.) honey against selected microbial isolates.** (diameter in mm./year of honey production)

Honey Concentration, (%)	Zone of inhibition							
	S. aureus		E. coli		C. difficile		Sal. enterica	
	Min.	Max.	Min.	Max.	Min.	Max	Min.	Max.
1	0.0	5	0.0	2	0.0	4	0.0	3
3	3	11	5	11	4	7	5	7
5	7	18	8	18	7	16	7	18
10	15	22	8	26/2008	9	24/2008	11	22/2008
25	18/2009	28/2008	9/2009	36/2010	9/2009	30/20010	10/2008	26/2008

S. aureus - Staphylococcus aureus; *E. coli* - Escherichia coli; *C. difficile* - Clostridium difficile; *Sal. enterica* - Salmonella enterica

Inhibition effect of different concentration of *Melaleuca* (*Melaleuca quinquenervia*) honey against selected microbial isolates. (diameter in mm./year of honey production)

Honey Concentration, (%)	Zone of inhibition							
	S. aureus		E. coli		C. difficile		Sal. enterica	
	Min.	Max.	Min,	Max.	Min.	Max	Min.	Max.
1	0.0	2	0.0	3	0.0	3	0.0	3
3	4	6	5	8	4	8	6	9
5	7	12	9	16	11	18	16	18
10	9	16	13	28/2007	15	27/2007	16	26/2010
25	12/2007	22/2008	18/2009	36/2009	18/2010	35/2009	18/2009	30/2007

S. aureus - *Staphylococcus aureus*; *E. coli* - *Escherichia coli*; *C. difficile* - *Clostridium difficile*; *Sal. enterica* - *Salmonella enterica*

The source of honey, region, time and the method of storage had diverse effects on the studied characteristics.

Our data showed that honey can preserve its antibacterial activity at least five years by decreasing its MIC approximately $6 \pm 0.5\%$. The MIC of melaleuca honey was significantly higher than the orange honey (on average 11%), and relatively comparable to the Brazilian peppertree (higher on average 4.5%).