


## The influence of pH on wound healing and bacterial growth

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## The influence of pH on wound healing and bacterial growth

pH is lower in healing wounds compared to chronic wounds

Lower pH reduces bacterial growth/survival

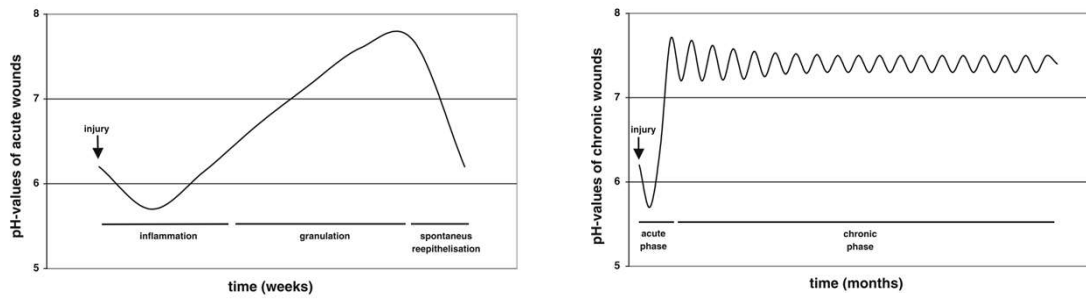


Acidifying wounds might improve healing and reduce bacterial burden



## pH in wounds

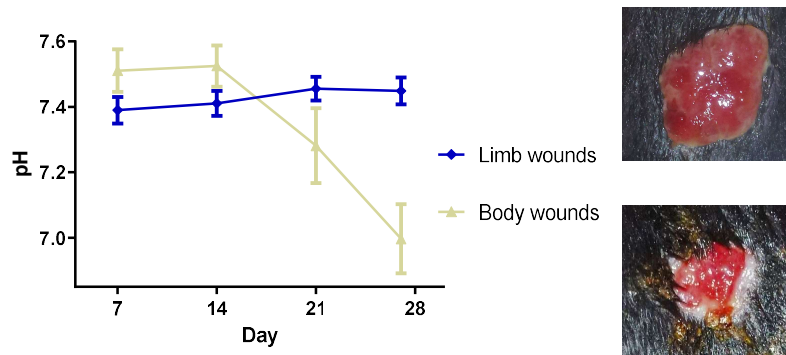
pH is lower in healing wounds compared to chronic wounds



Schneider et al. 2007, Qin et al. 2019

## pH in wounds

pH is lower in healing wounds compared to chronic wounds



Modified from Jørgensen et al. 2019

## pH in wounds

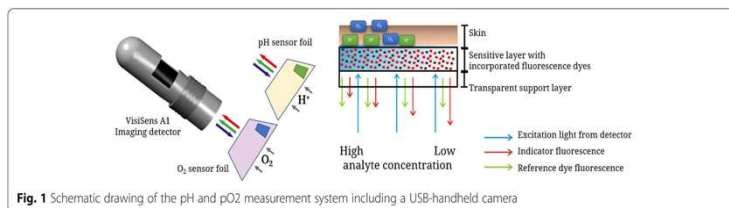
### Features associated with lower wound pH

- Improved cell-mediated immune response -> decreased chronic inflam.
- Improved antibacterial defence
- Stimulated fibroblast proliferation
- Decreased proteolytic activity
- Increased amount of oxygen available for the cells (Bohr-effect)
- Increased epithelium growth

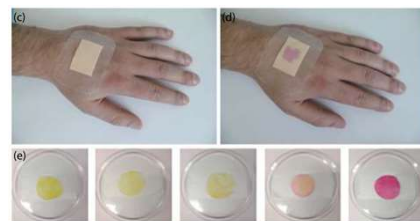
Jones et al. 2014, Nagoba et al. 2015, Percival et al. 2014, Rippke et al. 2018, Greener et al. 2005, Leveen et al. 1973, Schneider et al. 2007, Wilson et al. 1979

## pH in wounds

### Measuring pH can be used for wound diagnostics



Auerswald et al. 2019

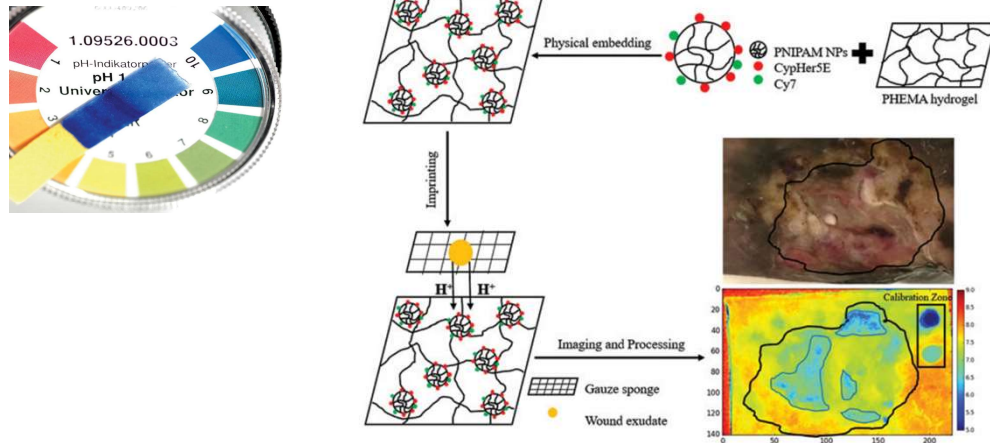


Qin et al. 2019

Jones et al. 2015

## pH in wounds

Measuring pH can be used for wound diagnostics



Li et al. 2020

Jones et al. 2015

## Lower pH reduces bacterial growth/survival

Increased skin pH -> increased infection risk

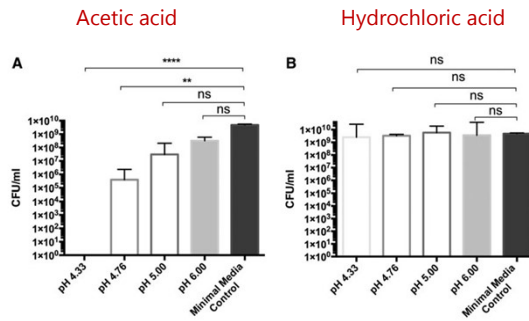
*Candida albicans* and *S. aureus* infections (e.g. diaper dermatitis)

Canine seborrheic dermatitis

Dogs have relative alkaline skin pH -> increased risk of dermatitis?

## Lower pH reduces bacterial growth/survival

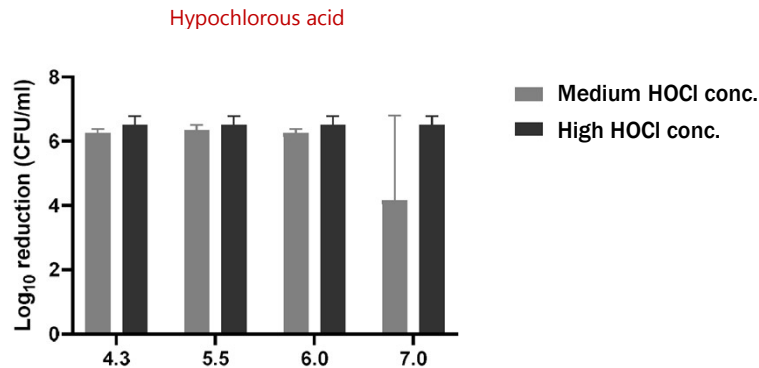
*P. aeruginosa* biofilms are killed by some acids at low pH



Bjarnsholt et al. 2015

## Lower pH reduces bacterial growth/survival

Planktonic *P. aeruginosa* are killed more easily at low pH



Unpublished data, Burian et al. 2021

## Lower pH reduces bacterial growth/survival

Less biofilm formation with decreasing pH

Strain		pH 5.5	pH 7.5	Increase (pH 7.5 vs. 5.5), in %	pH 8.5	Increase (pH 8.5 vs. 5.5), in %
<i>P. aeruginosa</i>	36/79	0.547 ± 0.043	0.742 ± 0.018	136	0.759 ± 0.030	139
	48/236	0.534 ± 0.048	0.744 ± 0.023	139	0.768 ± 0.050	144
	6819	0.172 ± 0.004	0.282 ± 0.017	164	0.411 ± 0.035	239
	5029	0.206 ± 0.008	0.330 ± 0.006	160	0.502 ± 0.017	244
<i>K. pneumoniae</i>	11/P/07	0.233 ± 0.016	0.333 ± 0.021	143	0.698 ± 0.039	300
	39	0.231 ± 0.008	0.333 ± 0.025	144	0.737 ± 0.040	319
	5041	0.141 ± 0.005	0.157 ± 0.009	111	0.213 ± 0.019	151
	58/274	0.066 ± 0.013	0.112 ± 0.012	170	0.129 ± 0.010	195
	59/275	0.066 ± 0.006	0.117 ± 0.010	177	0.133 ± 0.014	202

Hostacka et al. 2010

## Acidifying treatment of wounds

Acidifying wounds might improve healing

Acetic acid has been used for more than 100 years

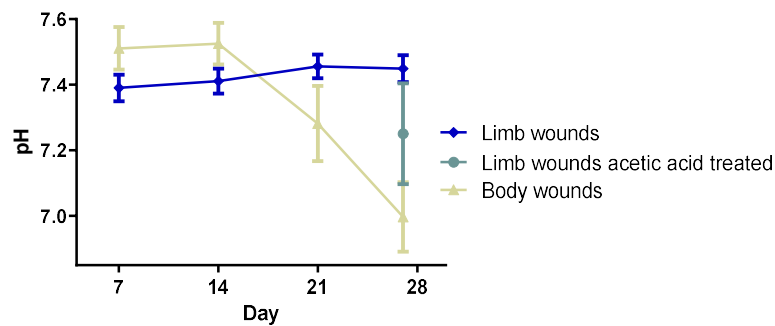


Phillips et al. 1968, Sloss et al. 1993, Taylor 1916, Jørgensen et al. 2021

## Acidifying treatment of wounds

Acidifying wounds might improve healing

Acetic acid has been used for more than 100 years



Modified from Jørgensen et al. 2019 + unpublished data

## Acidifying treatment of wounds

Acidifying wounds might improve healing

Acetic acid has been used for more than 100 years

Kills mature *S. aureus* and *P. aeruginosa* biofilms *in vitro*

Can improve wound bed quality and healing

Hypochlorous acid – similar properties as acetic acid, but more potent

Many other topical products are also acidic, e.g. honey

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