Soft Acid
Drinking water application

Borregaard

EMPLOYEES

1100

PRODUCTION

- Biopolymers
- Speciality cellulose
- Bioethanol
- Biovanillin
- Cellulose fibrils
- Fine chemicals

800
PRODUCTS

RAW MATERIAL

1 MILLION

m^3 Norway Spruce
375.000 tonnes lignin raw material

BORREGAARD IN THE WORLD

Business in **13** countries

Sales to **100** countries

Sales outside Norway **95** percent

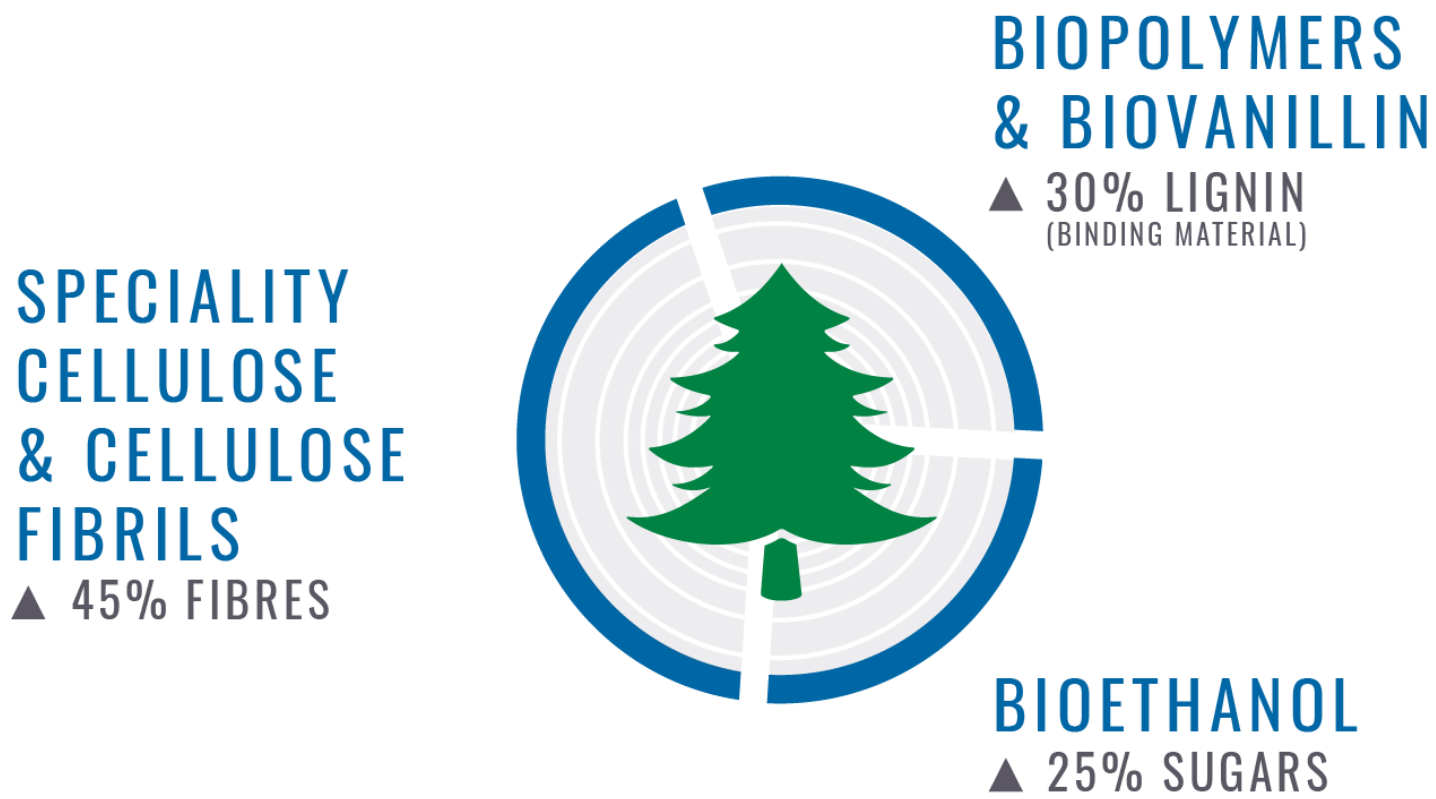
FINANCIAL FIGURES

Turnover **7.1** billion NOK

Result EBITDA **1.8** billion NOK

Investment **838** million NOK

Sustainable substitutes to petrochemicals



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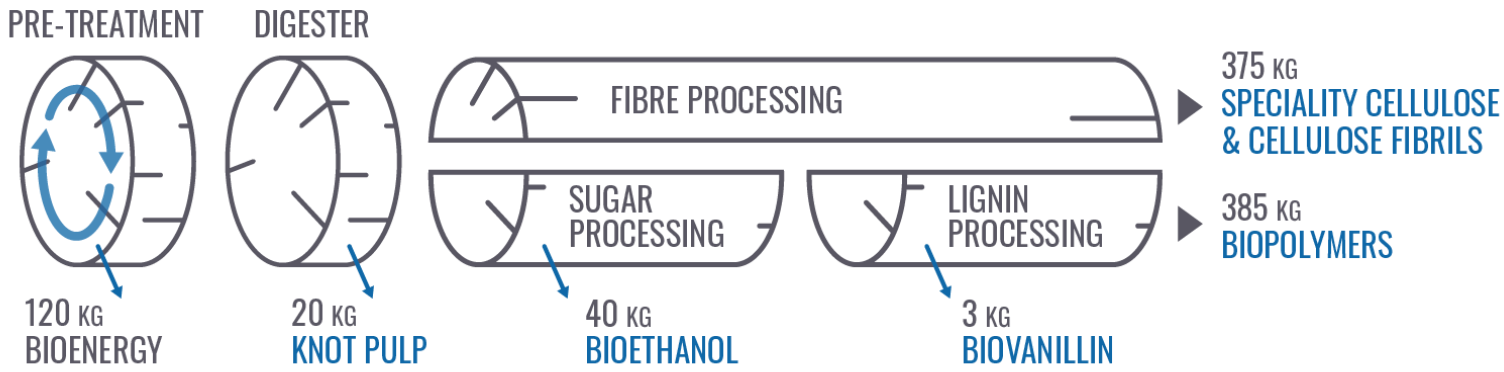
High utilisation of raw materials

1000 KG
WOOD

94%
UTILISATION



BIOPOLYMERS
Concrete additives
Animal feed
Agrochemicals
Batteries
Briquetting
Soil conditioning

BIOVANILLIN
Food
Perfumes
Pharmaceuticals

SPECIALITY CELLULOSE
Construction materials
Filters
Inks and coatings
Casings
Food
Pharma
Personal care
Textiles

CELLULOSE FIBRILS
Adhesives
Coatings
Agricultural chemicals
Personal care
Home care
Construction

BIOETHANOL
Biofuel
Disinfectants
Pharmaceutical industry
Home care
Personal care
Paint/varnish
Car care

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SoftAcid®

SoftAcid is a mixture of organic acids and lignosulfonic acid, which moderates the aggressive nature of the acids – hence the name Soft.

www.softacid.com

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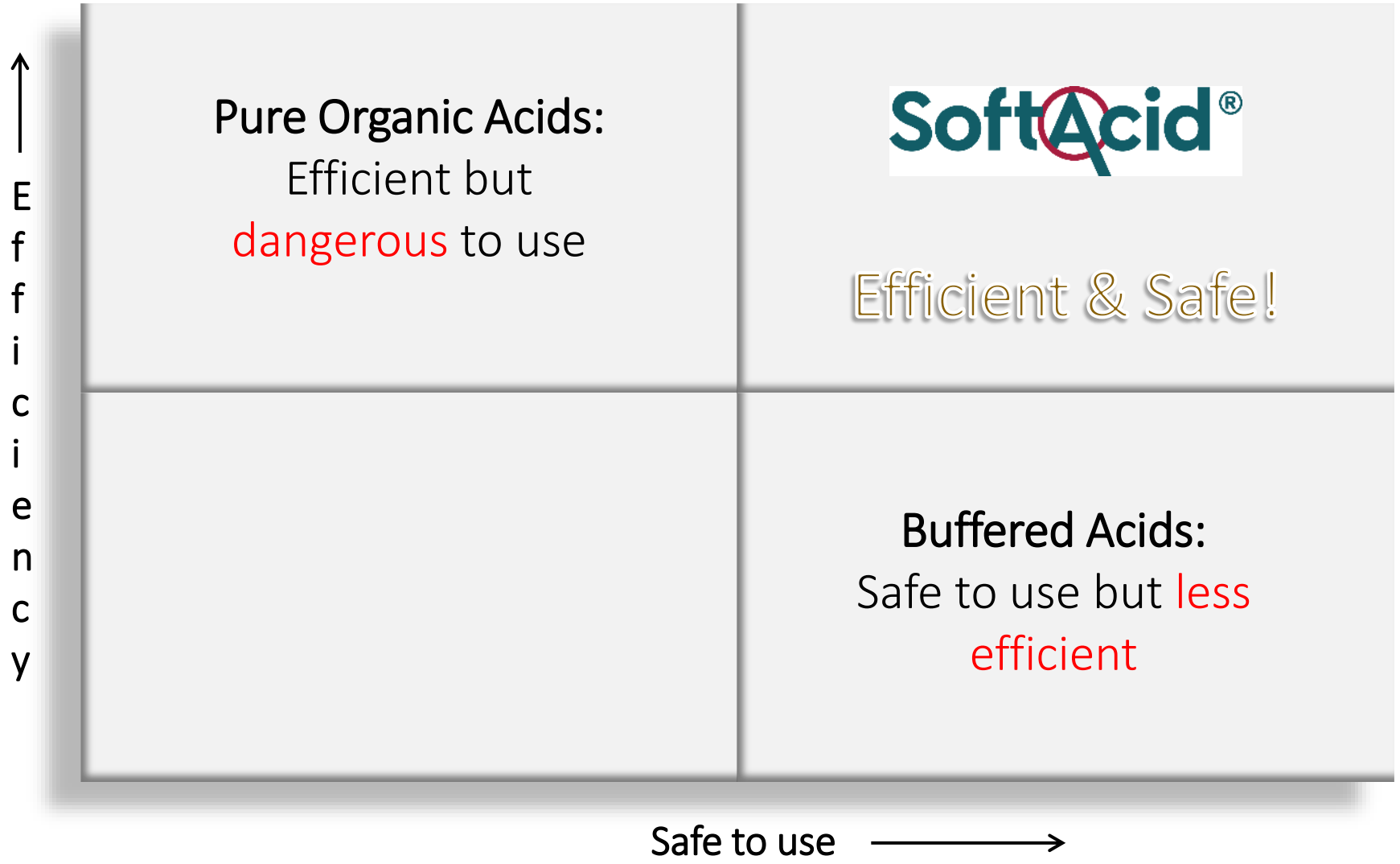
Traditional Acids

- Pure Organic Acids are efficient but corrosive and volatile
  - Classified as dangerous – Class 8
  - Formic Acid : 20-30% weight loss in average during a pig pellet process by evaporation
  - < pH 2.8 (Formic Acid) Animals stop drinking because of smell

- Buffered Organic Acids: less corrosive but also less efficient
  - In sodium formate, the molar weight of sodium represents 34% of the total weight without any bacterial or nutritional effect
  - pH close to the pKa (around 4.5 for organic acids). The bacterial effect due to low pH is therefore significantly reduced

Why Use SoftAcid?



SoftAcid – An Unique Concept

Unique and patented technology

- Organic Acids protected by lignosulfonic acid

SoftAcid vs pure organic acids:

- Irritant / not classified as Dangerous
- Far less corrosive on metal and concrete
- Low volatility/evaporation and smell
- Safer to use - Easier to handle
- Provides bacterial inhibition making SoftAcid the only 2 in 1 solution (bactericidal and bacteriostatic)
- Reduces biofilm adhesion

Competitive solution in terms of price

SoftAcid From a Molecular Point of View

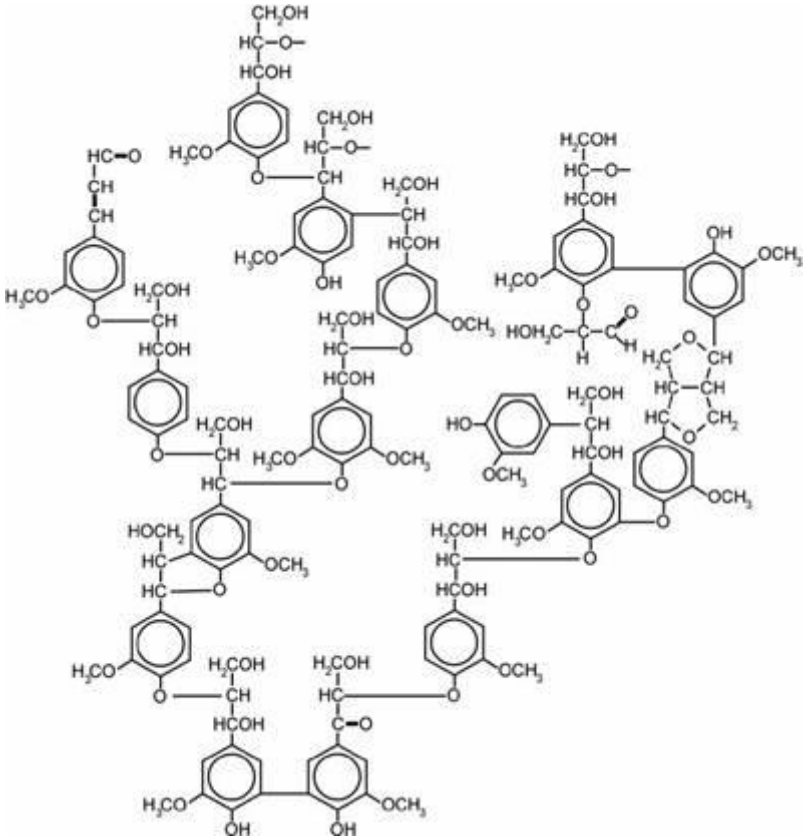
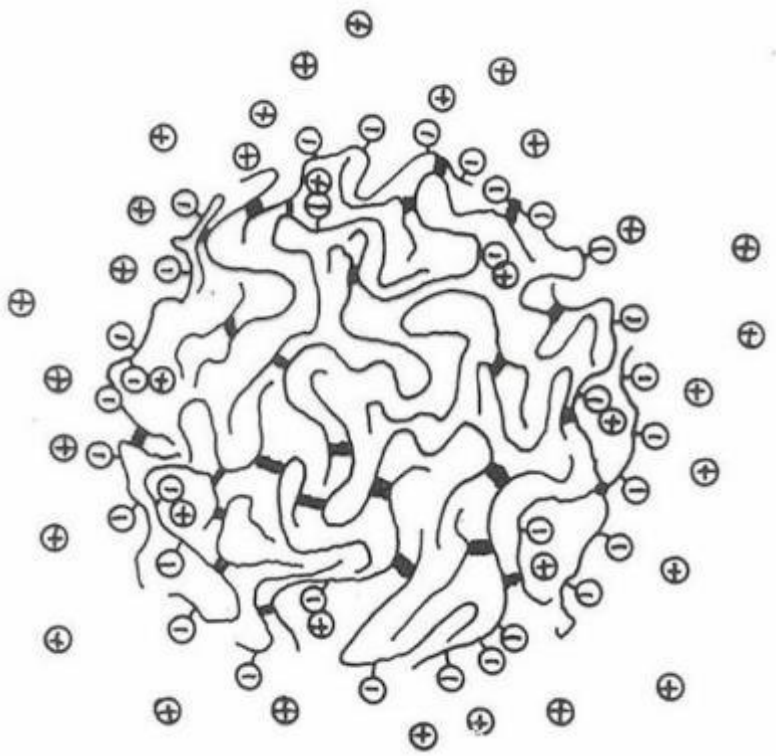
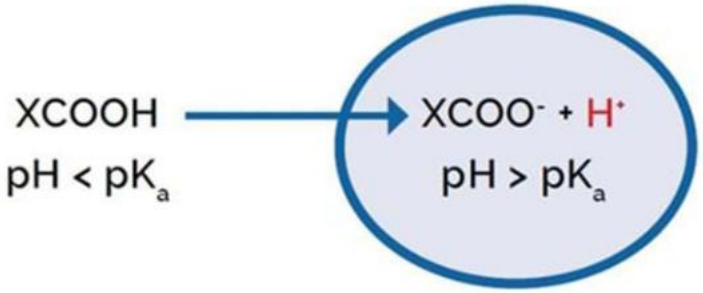


Fig.1 : Lignin structure - Monomer of the lignosulfonic acid used in SoftAcid

Fig. 2 : Schematic structure of the natural based polymer of lignosulfonic acid used in SoftAcid



Mechanism of action



Undissociated acid diffuses through the semi-permeable cell wall of the microorganism

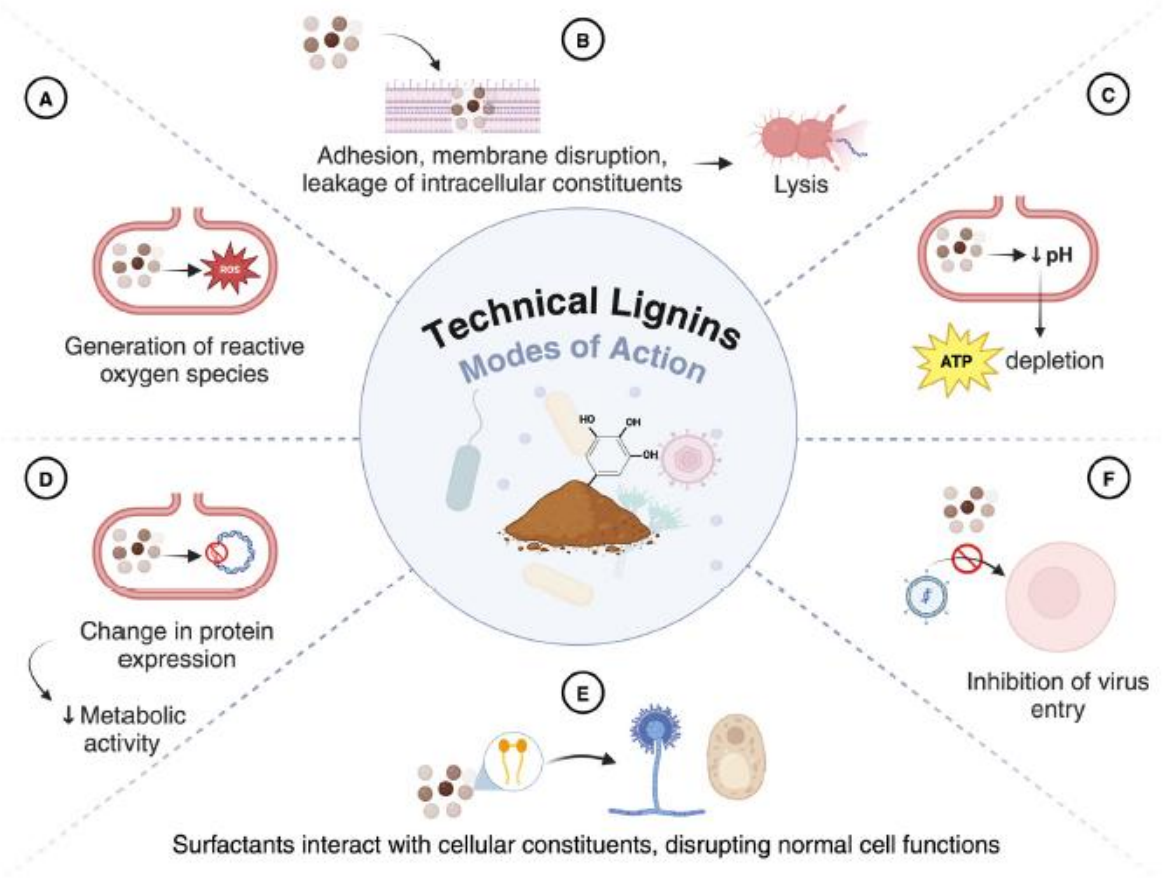
Organic acids have two functions as antimicrobial agents. Their primary antimicrobial action is through pH depression.

In addition, the ability of the organic acids to change from undissociated to dissociated form, depending on the environmental pH, makes them effective antimicrobial agents.

An acid in the undissociated form can freely diffuse through the semipermeable cell wall of the microorganism into their cell cytoplasm.

Once inside the cell, where the pH is maintained near 7, the acid will dissociate: The H+ ion releases and as a result the pH will decrease. A change in pH will suppress cell enzymes and nutrient transport systems (Lueck, 1980).

Antimicrobial mechanisms of technical lignins and their derivatives.



- (**A**) Lignin polyphenols induce oxidative stress within bacterial cells by generating reactive oxygen species (ROS), thereby causing cellular damage [6,28];
- (**B**) lignin nanoparticles penetrate bacterial cell walls, disrupting membranes and altering permeability, leading to cell lysis [28,29];
- (**C**) the generation of ROS reduces intracellular pH and depletes ATP [28];
- (**D**) lignin particles bind with cytoplasmic components, potentially altering or inhibiting the expression of key metabolic proteins [28,29];
- (**E**) certain lignin types possess strong surfactant properties that interact with lipids and proteins, adversely affecting fungal growth and viability [30,31];
- (**F**) lignin particles interfere with viral entry by interacting with virus envelopes [8].

Reyes et al., 2024. Polymers, 16, 2181. https://doi.org/10.3390/polym16152181

Summary of the antimicrobial activity tests of lignosulfonates.

polymers

MDPI

Review

The Antimicrobial Properties of Technical Lignins and Their Derivatives—A Review

Diana Carolina Reyes [1,2], Zhengxin Ma [3] and Juan Jose Romero [1,*]

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[3] Molecular and Biomedical Sciences, University of Maine, Orono, ME 04469, USA; zhengxin.ma@maine.edu
* Correspondence: juan.romero@maine.edu; Tel.: +1-207-581-2925; Fax: +1-207-581-2999

Effective against:

- E. coli
- S. aureus
- Streptococcus pyogenes
- S. enterica
- L. monocytogenes
- A. niger
- S. cerevisiae

- Aspergillus niger
- Penicillium expansum
- Aspergillus amoenus
- Mucor circinelloides
- Penicillium solitum
- Debaromyces hansenii

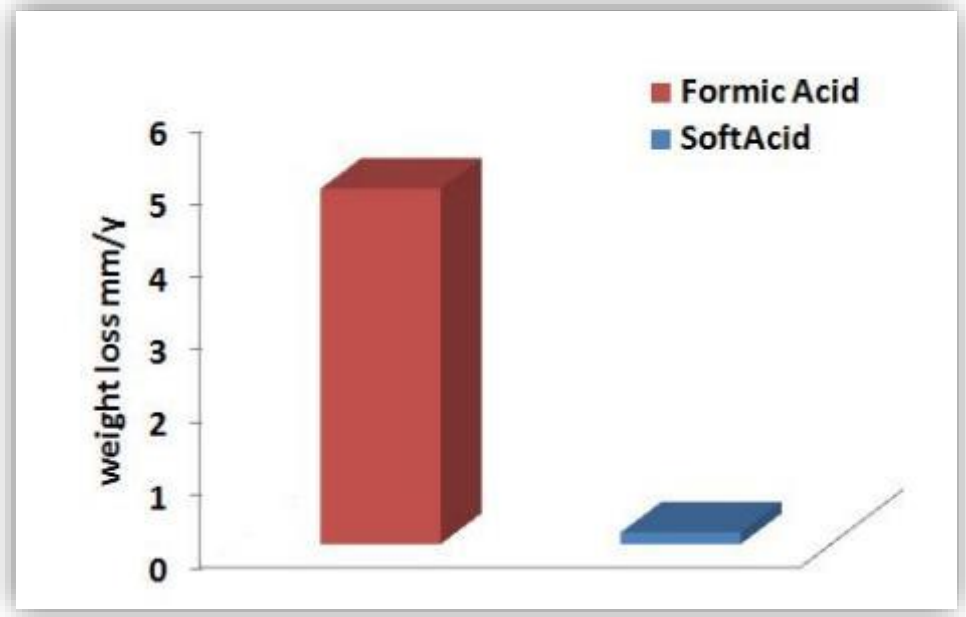
Table 1. Summary of the antimicrobial activity tests conducted in cited studies.

Technical Lignin	Pathogens Tested	Antimicrobial Test Method	Reference
Sodium lignosulfonate	*Candida dubliniensis* *C. tropicalis* *C. albicans* *C. glabrata* *C. parasilopsis*	MIC [1]; Disk diffusion assay	[7]
Sodium lignosulfonate	*D. hansenii* *Aspergillus niger* *Penicillium expansum*	Disk diffusion assay	[30]
Sodium lignosulfonate; magnesium lignosulfonate; alkali kraft lignin; southern pine kraft lignin (LBKL); LBKL acetone-insoluble;	*Aspergillus amoenus* *Mucor circinelloides* *Penicillium solitum* *Debaromyces hansenii*	Broth antimicrobial assay; MIC at different pH levels	[31]
Sodium lignosulfonate	*A. amoenus* *M. circinelloides* *P. solitum* *D. hansenii*	MIC and MFC [2]	[32]
Lignosulfonate nanoparticles	*Staphylococcus aureus* *Bacillus subtilis* *Escherichia coli*	Turbidimetric method	[11]
Sodium lignosulfonate; magnesium lignosulfonate; alkali kraft lignin; LBKL	*Streptococcus uberis* *Staphylococcus hyicus* *E. coli* *Klebsiella pneumoniae* *Pseudomonas aeruginosa*	MIC and MBC [3]	[33]
Lignosulfonate	HIV [4]	Virus antigen expression; cytopathic effect evaluation; cell-to-cell infection; reverse transcriptase assay	[34]
Lignosulfonic acid	HIV HSV [5]	Virus replication assay; virus time-of-drug-addition assay; virus inactivation assay; in vivo antiviral activity in mice	[8]
Kraft lignins; soda lignins	*E. coli* *Bacillus mycoides* *B. subtillis* *A. niger*	Disk diffusion assay	[35]
Kraft black liquor	*Coniophora puteana* *Poria placenta*	Wood protection from fungal degradation	[36]
Alkali kraft lignin	*Candida lipolytica* *S. aureus* *Listeria monocytogenes*	MIC	[6]
Kraft spruce lignins; Kraft eucalyptus lignins	*A. niger* *B. thuringiensis* *E. coli* *Enterobacter aerogenes* *Proteus microbilis* *P. vulgaris* *S. aureus*	Fungal growth inhibition test; disk diffusion assay	[37]
Bamboo kraft lignin (BKL); BKL 95% ethanol soluble fraction; BKL 95% ethanol insoluble fraction	*S. aureus* *B. subtilis* *E. coli* *Salmonella enterica*	MIC; agar diffusion assay	[38]

Reyes et al., 2024. Polymers, 16, 2181. https://doi.org/10.3390/polym16152181

Technological Benefits: Reduced Corrosion

- SoftAcid is far less corrosive on carbon steel and other metals than formic acid
- The aggressive nature of organic acids is reduced by the presence of lignosulfonic acid

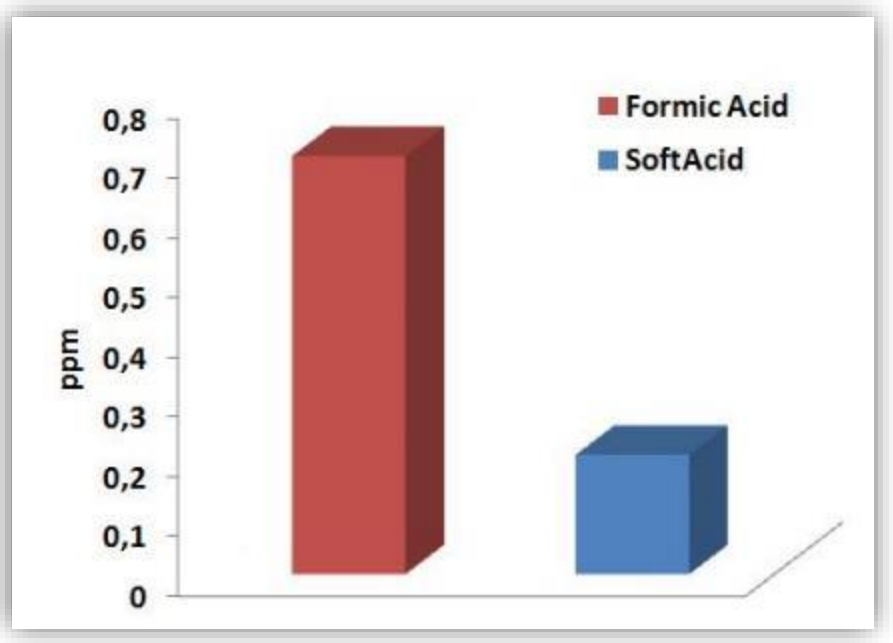


Corrosion on carbon steel was reduced by more than 95% with SoftAcid (vs pure formic acid).
Source: SINTEF Materials technology

Technological Benefits: Reduced Odour/Evaporation

- 15-20% of organic acids used in feed, grains and cereals are lost via evaporation
- Organic acids also emit malodours that pose great health risks to both humans and animals
- SoftAcid reduces the evaporation of organic acids, which leads to an increased efficiency over time

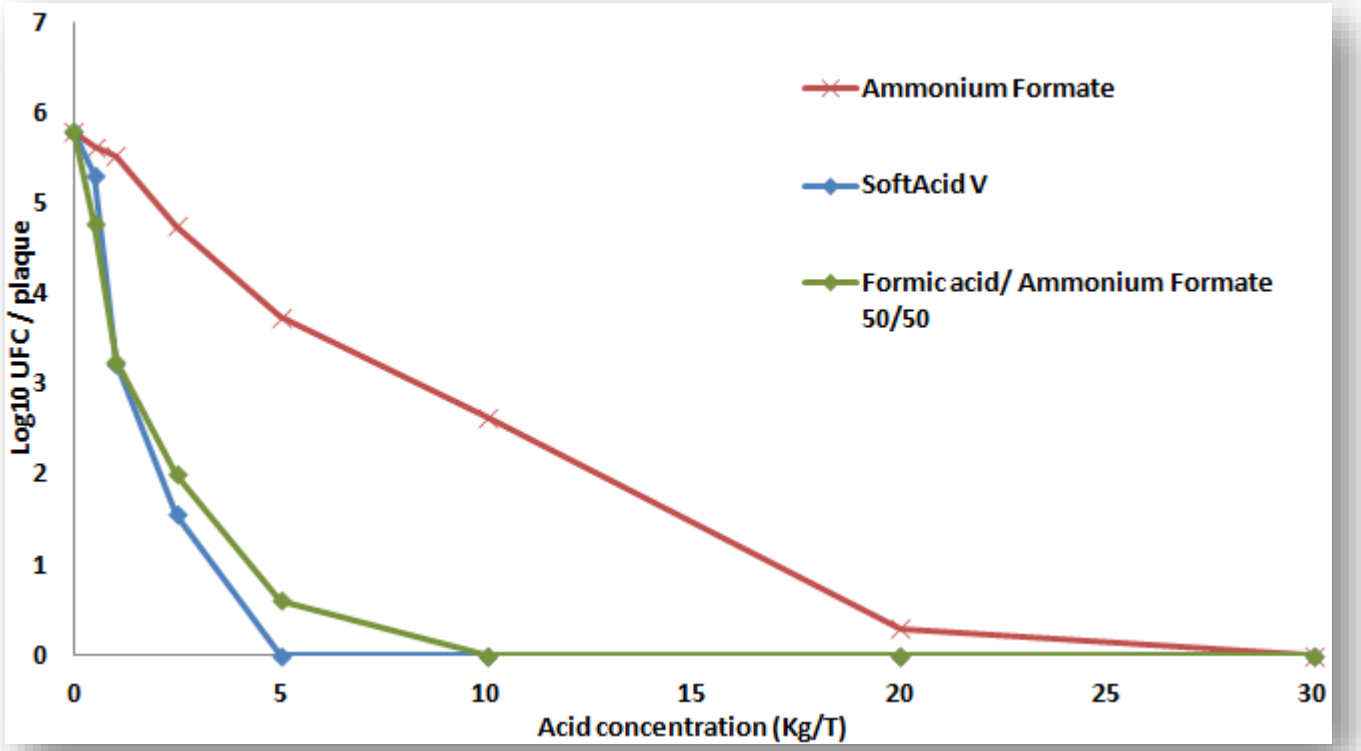
Acid levels in the air were monitored in a feed mill :



Production of feed pellets containing formic acid. The amount of formic acid present in the air was greatly reduced when formic acid was replaced by SoftAcid

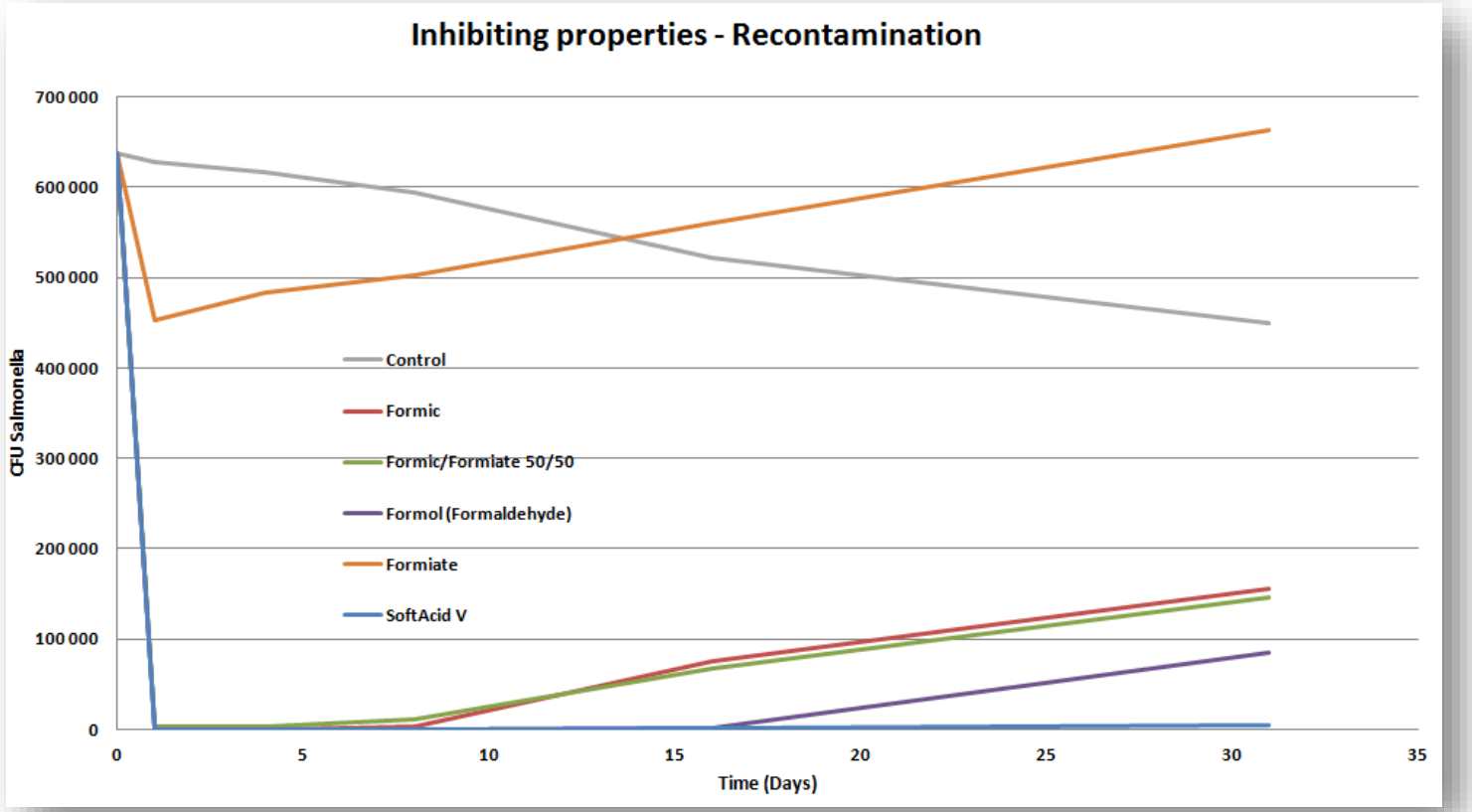
Laboratory Trials on *Salmonella* (1)

- Trials conducted with QuestPharma in Spain
  - Effect of different acidifiers on *Salmonella choleraesuis*
- SoftAcid V is far more efficient than Ammonium Formate and buffered acids.



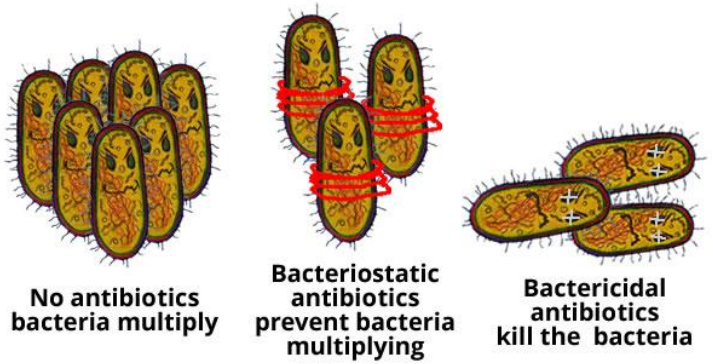
Laboratory Trials on *Salmonella* (2)

- The risk of *Salmonella* recontamination is strongly reduced with SoftAcid
  - SoftAcid V is the ONLY product with a documented long-lasting effect



Trials conducted with QuestPharma in Spain

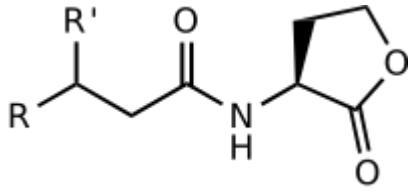
Lignosulfonic acid has bactericidal and bacteriostatic effect



Laboratory Trials on *Salmonella* (3) / Quorum sensing

- Signaling molecules capture (Quorum Sensing)

- Basically, most of those signalling molecules have the following chen formula (lactone formula):



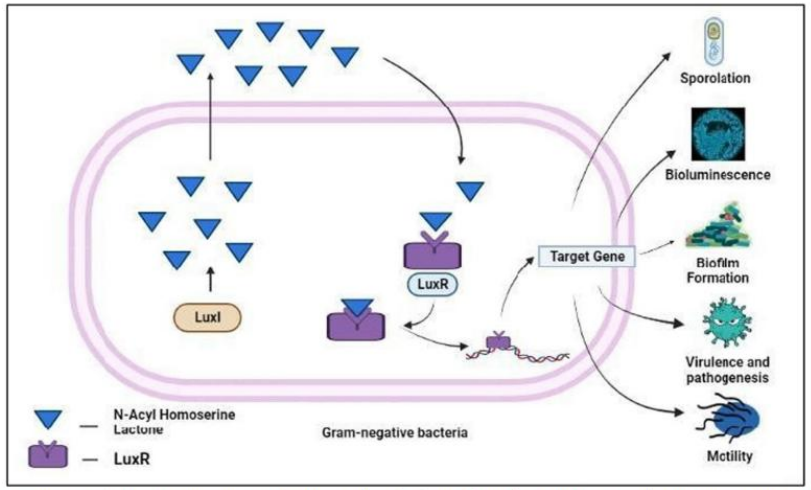


Fig. 2 Quorum sensing mechanism in Gram-negative bacteria involves the biosynthesis of autoinducer, N-Acyl Homoserine Lactone produced from LuxI followed by attachment of the autoinducer on LuxR receptor which leads to target gene transcription

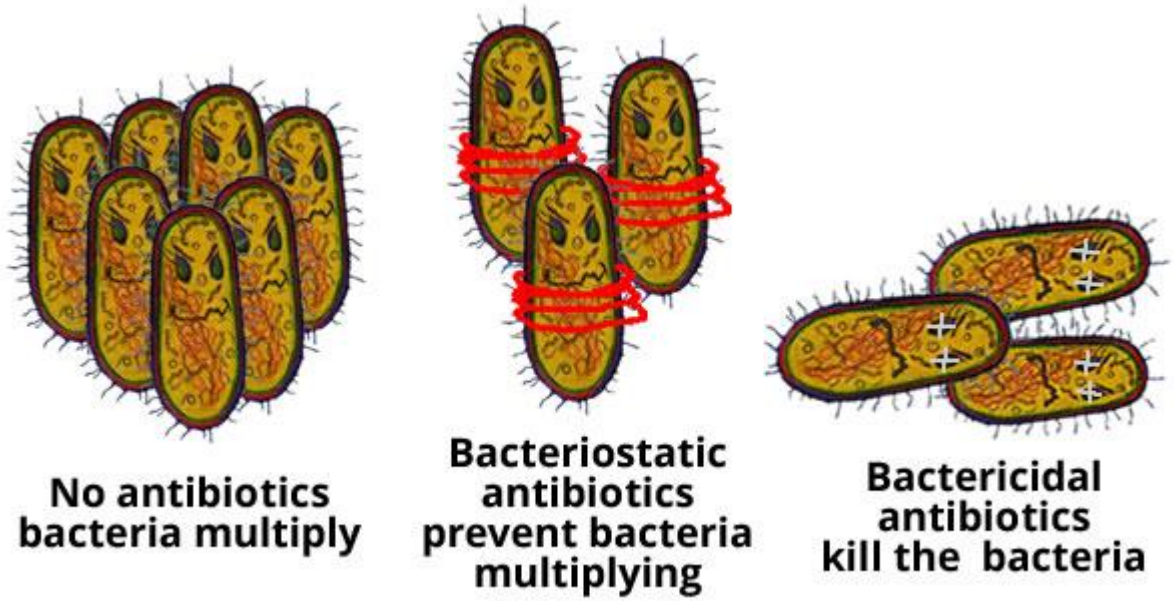
Boban et al. Future Journal of Pharmaceutical Sciences (2023) 9:77

- Those lactones have a NH group which is attracted by lignosulfonic acid as described in the Alwatech process. If those signalling molecules are caught by our lignosulfonic acid then we can consider that each bacteria is blind and and thus is not growing and dividing but more likely trying to survive

Laboratory Trials on Salmonella (3) / Quorum sensing

- SoftAcid is the only bactericidal and bacteriostatic product on the market

- Pure organic acids (classical blends) are purely bactericidal, meaning not the best choice in case of recolonization



Mould inhibition

- Main strains found in feed and cereals are :
  - Fusarium
  - Aspergillus

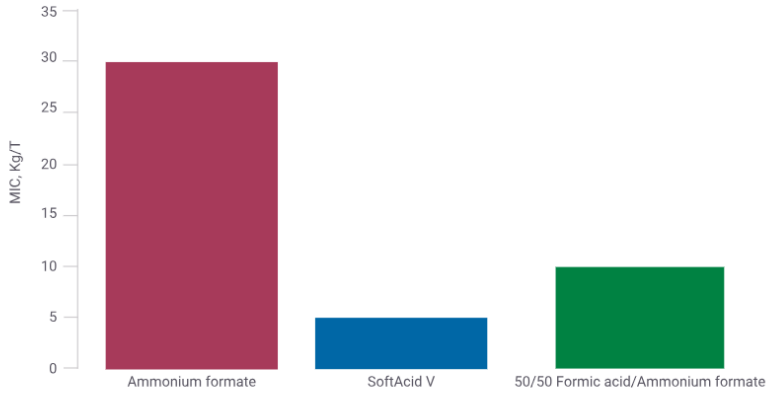
- Molds have different tolerance to low pH than bacteria's.
  - Clear inhibition between 3 and 5
  - Stimulation at low pH
  - Stimulation at high pH

- Thus having a too strong acid on molds is not always a good strategy

Laboratory trials conducted with QuestPharma in Spain

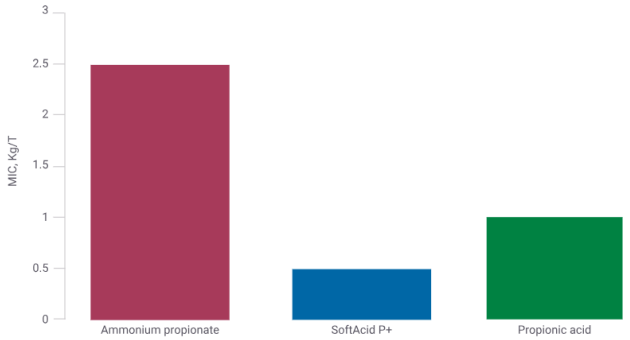
Salmonella

- SoftAcid V is far more efficient than ammonium formate.



Fusarium

- SoftAcid P+ is very efficient on fusarium, even at low inclusion rate (0.5 kg/t).
- Propionic acid is less efficient than SoftAcid P+ in inhibiting fusarium (1 kg/t to achieve the same effect).
- Ammonium propionate requires an even higher dose (2.5 kg/t) than propionic acid to achieve the same results.

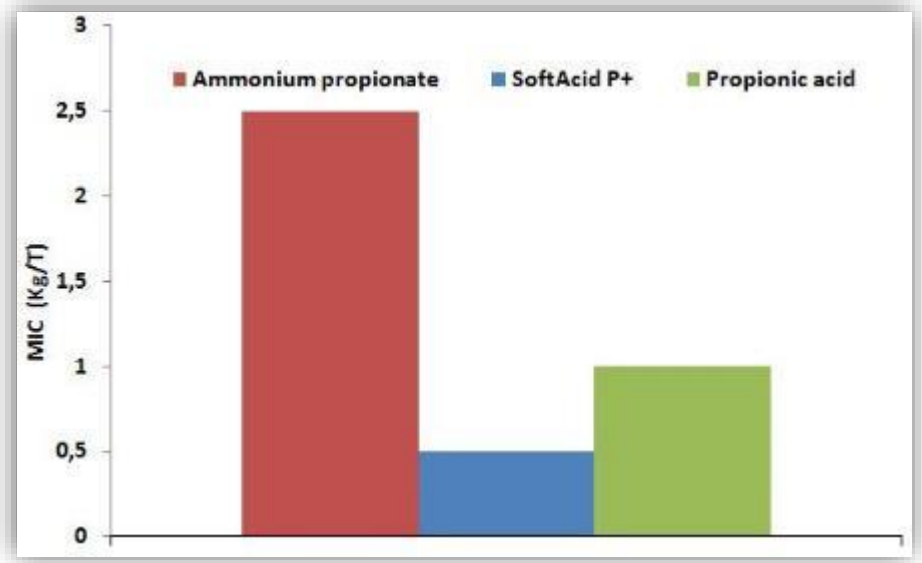


Different acid formulations were tested on Salmonella Choleraesuis and Fusarium Verticiloides. Clear benefits with SoftAcid® were observed.

The figures show the results of minimum inhibitory concentration (MIC) tests with different acidifiers.

Laboratory Trials on *Fusarium*

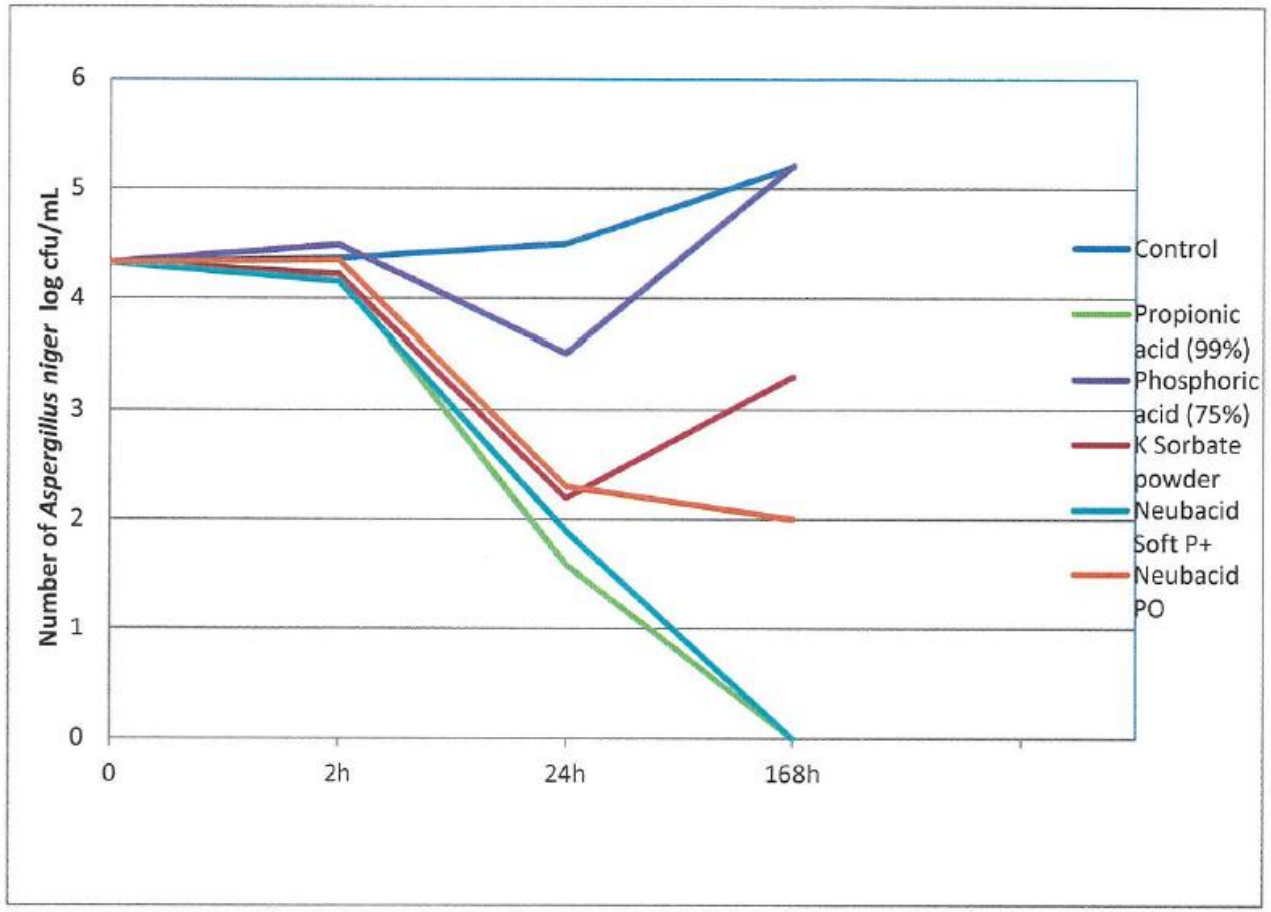
- SoftAcid P+ is very efficient on *Fusarium* even at low inclusion rate: 0.5 kg/t
- 1 kg of Propionic acid is needed to get the same effect
- Ammonium propionate requires 2.5 kg/t
- Propionic acid has its strongest antifungal activity in the range between pH 4.5 to 5.0. As a result, pH in the sample treated with pure propionic acid is too low, and a higher MIC can be observed. Similarly, the pH in the sample treated with propionate is too high, resulting in the same drop in efficiency.



MIC (Minimum Inhibitory Concentration) for different acidifiers vs *Fusarium Verticiloides.* Trials conducted with QuestPharma in Spain.

Propionic Acid (0,5Kg/T)	*Amm Propionate (0,5Kg/T)*	*SoftAcid P+ (0,5Kg/T)*
		

Reduction of the number of **Aspergillus niger** in liquid medium

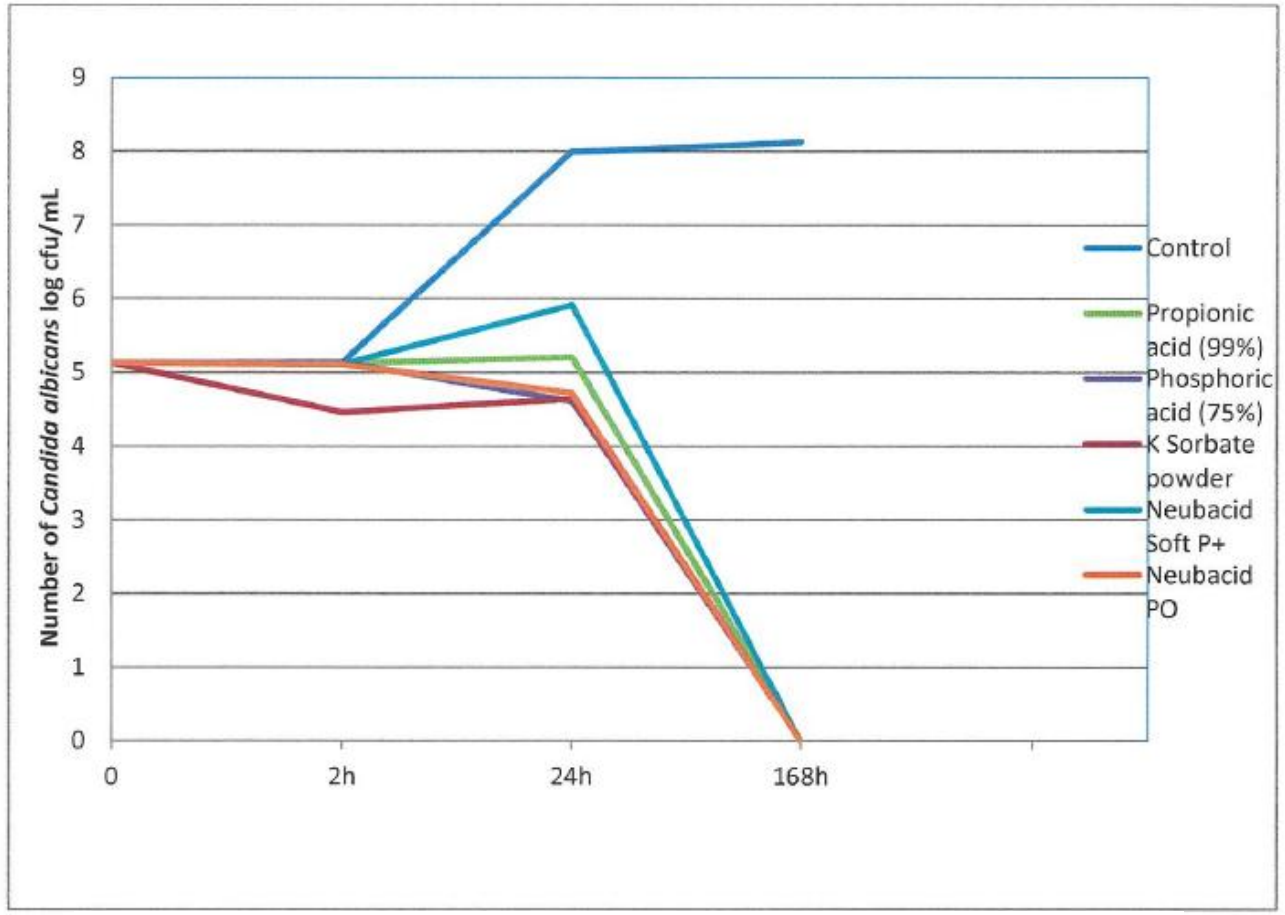


WROCŁAW UNIVERSITY OF ENVIRONMENTAL AND LIFE SIENCES
DEPARTMENT OF FOOD HYGIENE AND CONSUMER HEALTH PROTECTION
Faculty of Veterinary Medicine

C. K. Norwida 31, 50-375 Wrocław, tel. 71 32 05 171

Wrocław, February 11, 2025

Reduction of the number of **Candida albicans** in liquid medium



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Wrocław, October 28, 2024

SoftAcid Applications

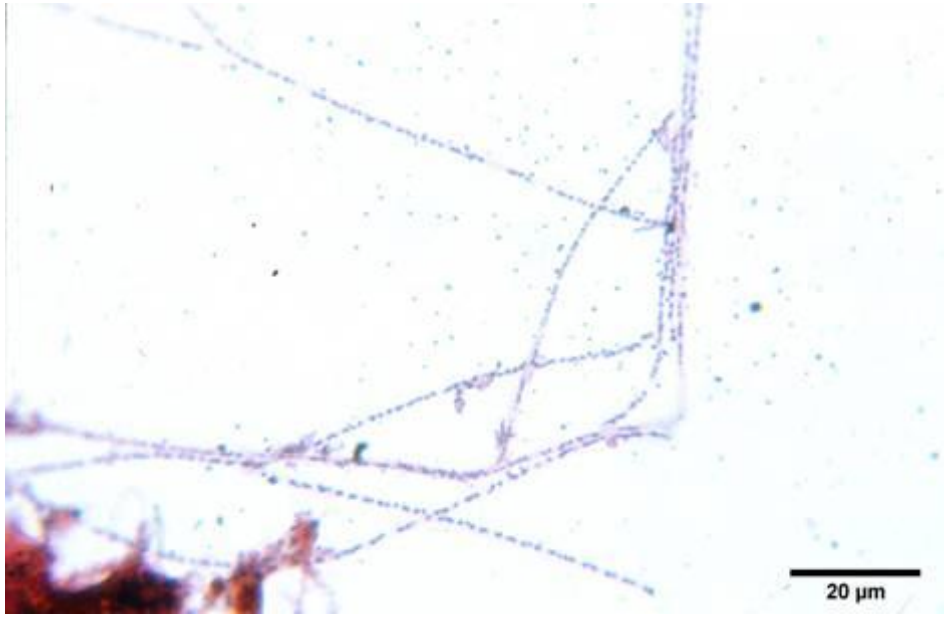
Fish Preservation	Fish Silage Preservation	Pig Feed	Piglet Feed	Poultry Feed
				

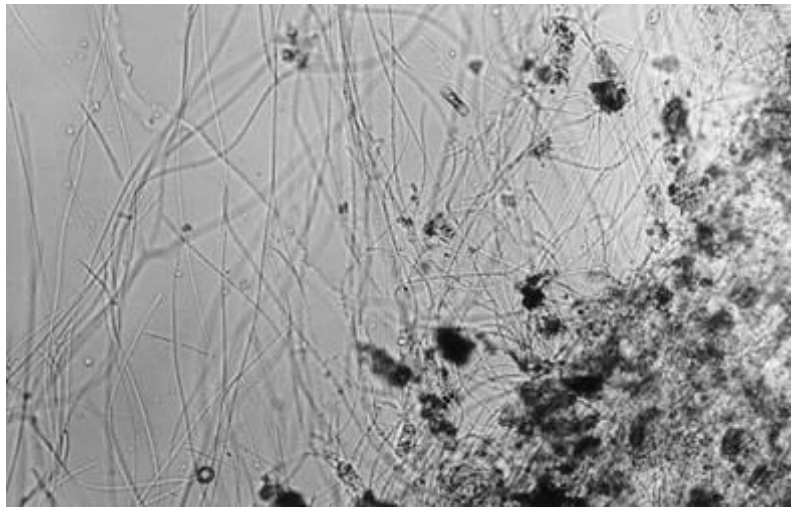
Drinking Water Systems	Wet Feeding	Silage Preservation	Cereal and Raw Material Preservation	TMR
				

Biofilm adhesion reduction

SoftAcid contains some products used for a long time ago in several industries to precipitate proteins (Alwatech Process). This compound build a strong link with bacterias (such as filamental bacterias) and remove them from walls and pipes.

Moreover SoftAcid acidity destroys tartar which is a perfect media to grow this type of biofilm





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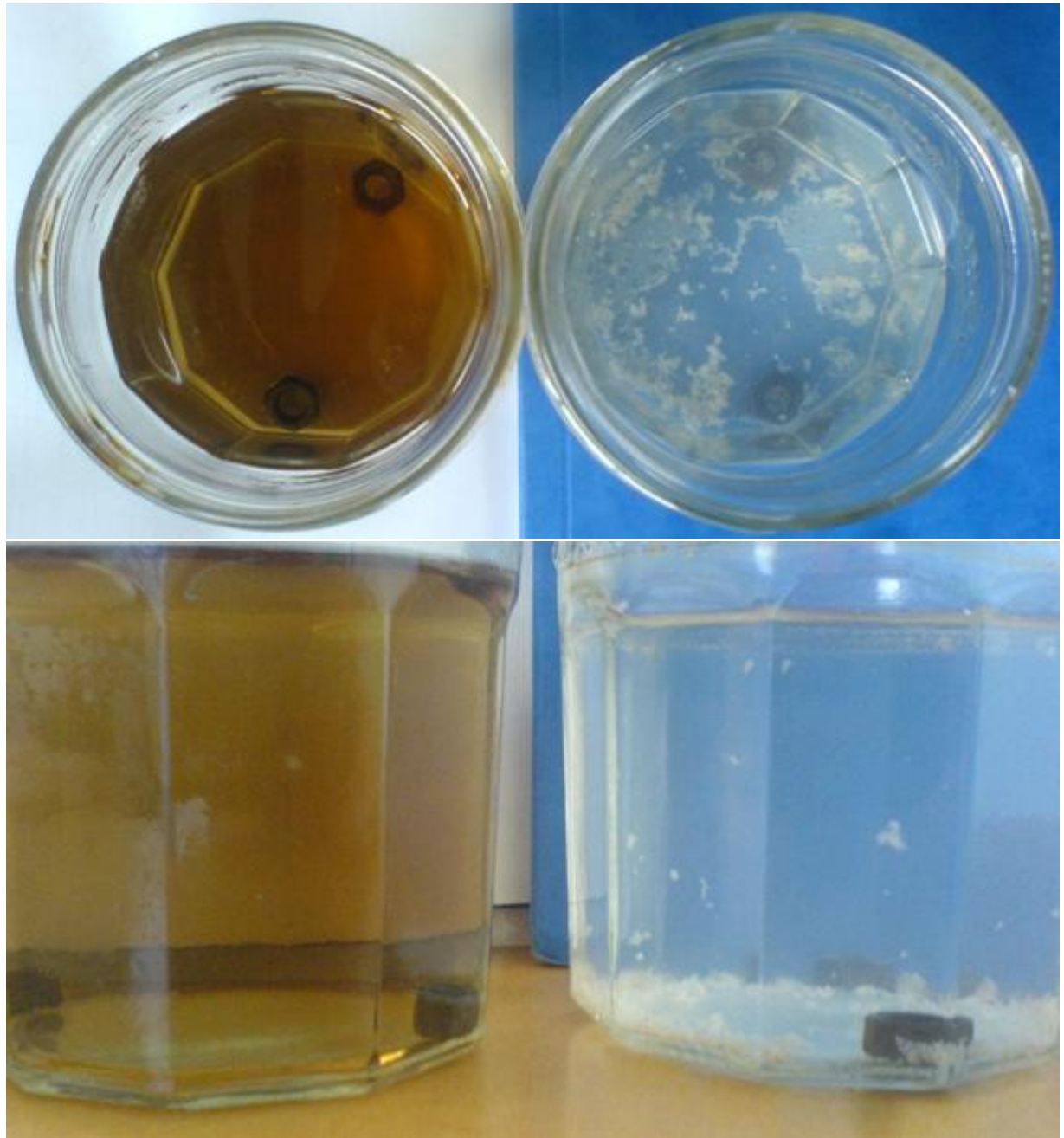
SoftAcid

Formic Acid

After one week, a biomass appears in formic acid : resistant biofilm on enterobacterias

Nothing in SoftAcid as shown on pictures



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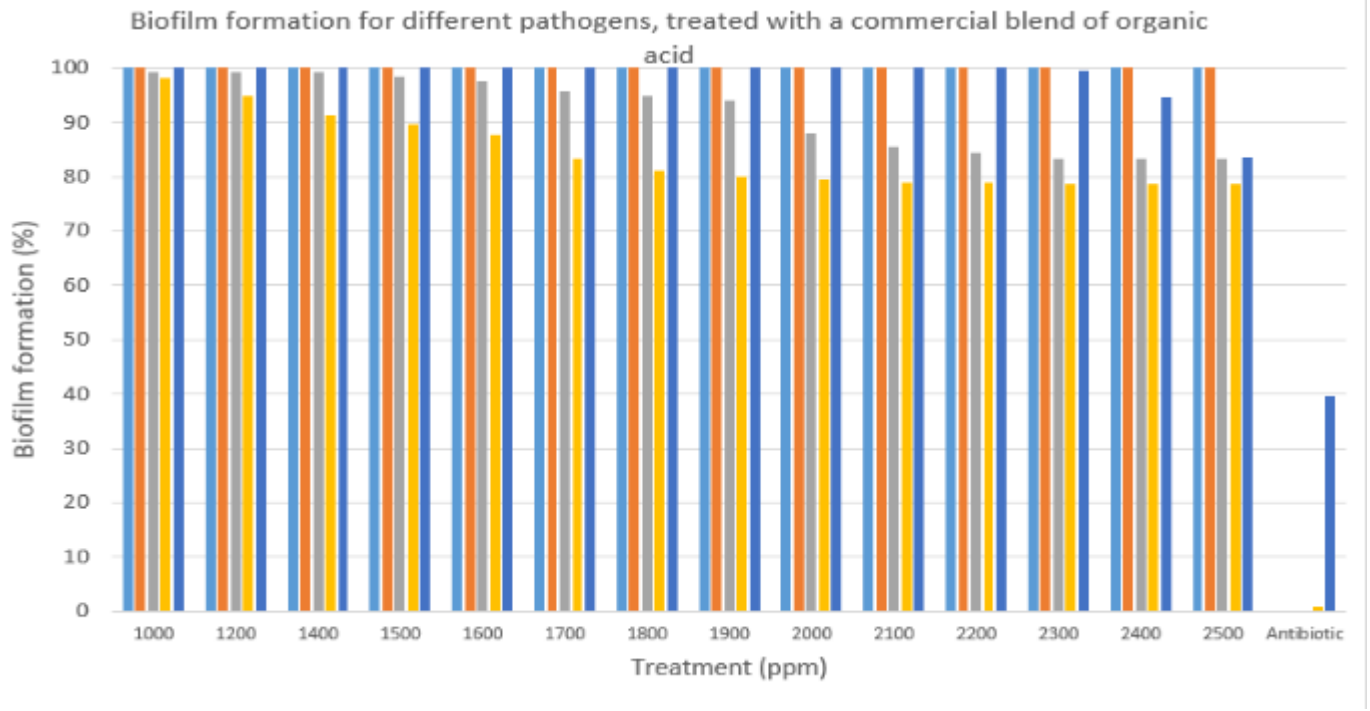
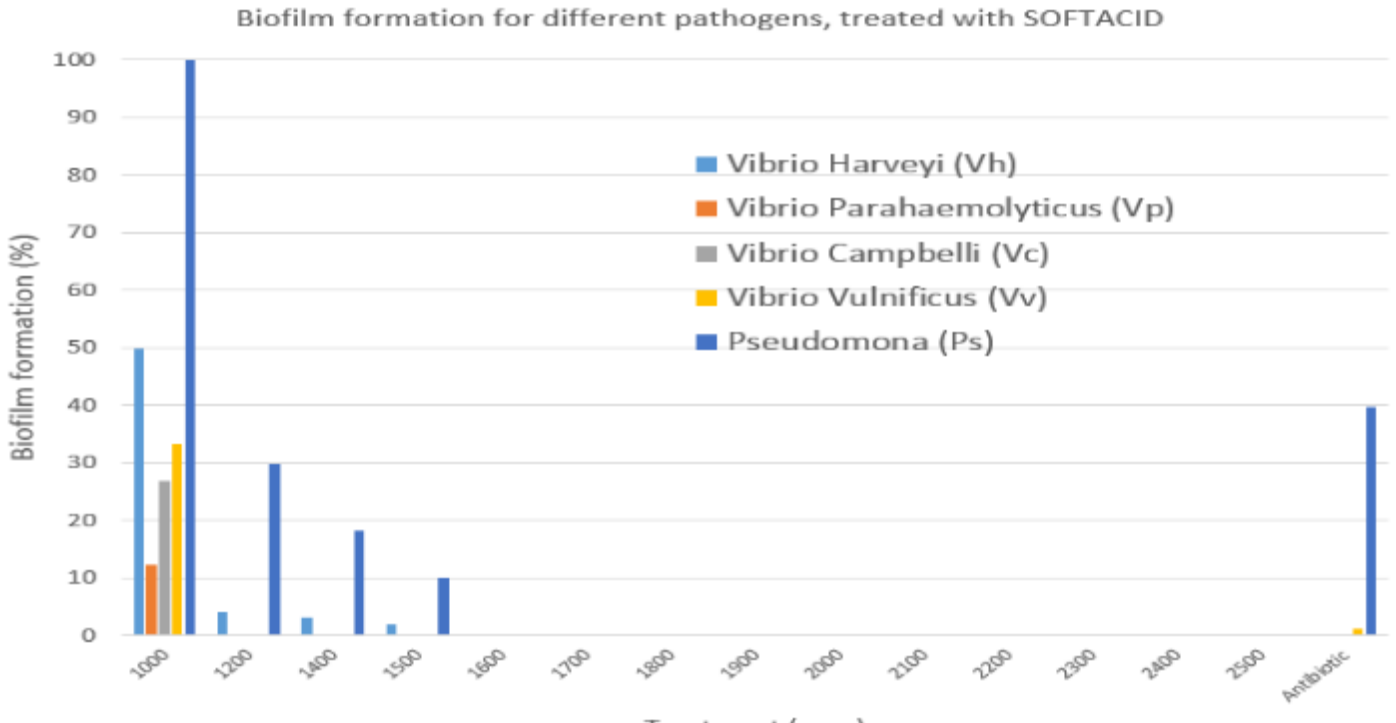

Biofilm formation for different pathogens, treated with a commercial blend of organic acid
Biofilm formation (%)
100
90
80
70
60
50
40
30
20
10
0
1000
1200
1400
1500
1600
1700
1800
1900
2000
2100
2200
2300
2400
2500
Antibiotic
Treatment (ppm)


Biofilm formation for different pathogens, treated with SOFTACID
Biofilm formation (%)
100
90
80
70
60
50
40
30
20
10
0
Vibrio Harveyi (Vh)
Vibrio Parahaemolyticus (Vp)
Vibrio Campbelli (Vc)
Vibrio Vulnificus (Vv)
Pseudomona (Ps)
1000
1200
1400
1500
1600
1700
1800
1900
2000
2100
2200
2300
2400
2500
Antibiotic

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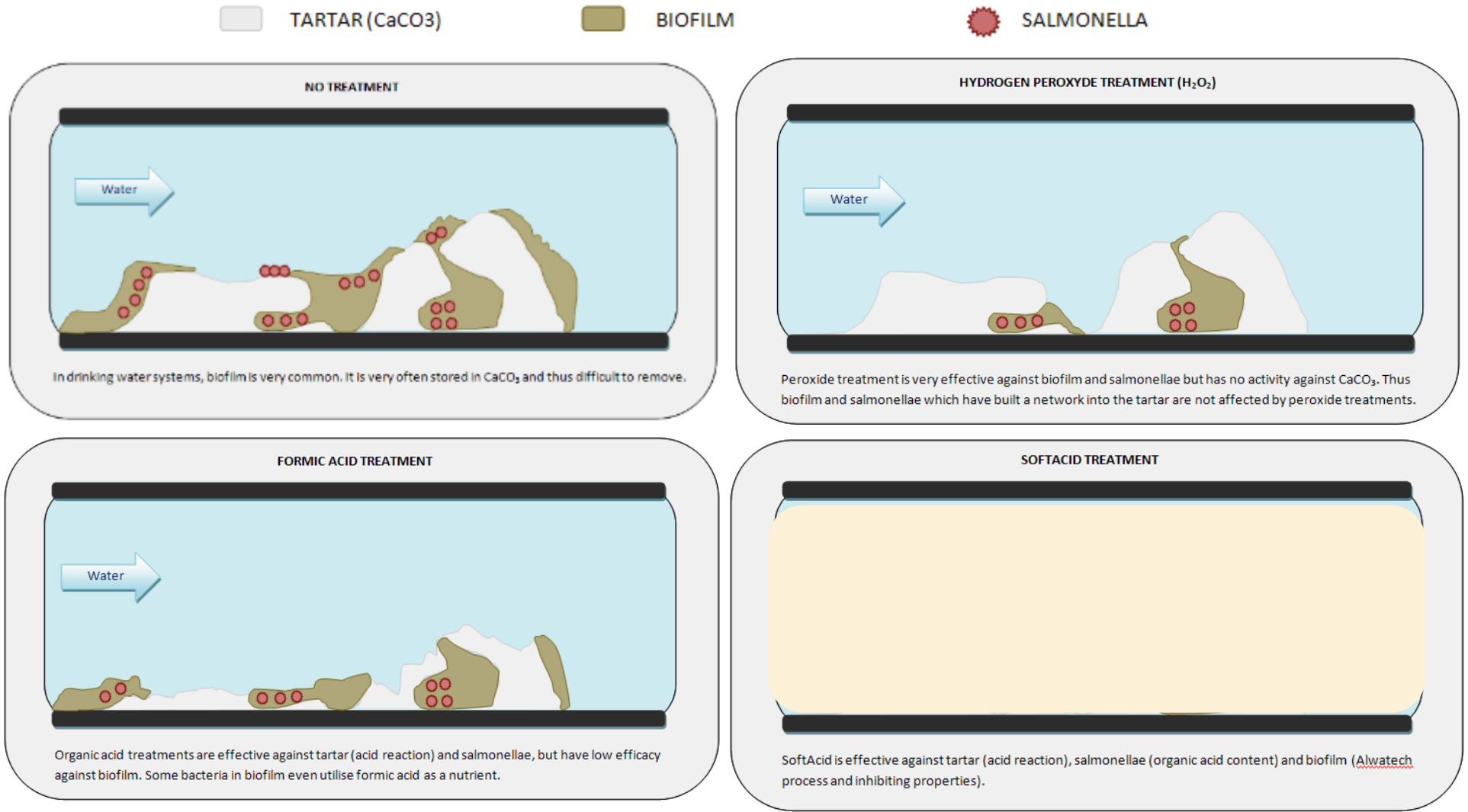
SoftAcid
Biofilms / Hypothesis

1. In Drinking water systems



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Drinking water application – How to use it?

1. Cleaning!

- All pipes / drinking water systems are contaminated with biofilms
- Chlorination has limited effect on biofilm as tartar will not be removed
- Normal acidification has limited effect as acids are to corrosive to be properly used
- Moreover some bacterias have developed bioresistance to organic acids
- Buffered acidification has no effect on biofilms

2% during 2H (maximum 2hours)

- Fully opened nipples
- When clear water is coming, remove SoftAcid and flush all the system with neutral fresh water
- Animals are preferably removed during this operation but it can be done with the animals

Drinking water application – How to use it?

2. Acidification

- We don't target an inclusion rate but a pH
- Best window: 3,8 to 4,2
- It means usually around 0,1% inclusion rate
- It can be controlled by pH paper (acidic one) or pH meter (calibrated)
- If you wash your pipes correctly and you keep a good SoftAcid acidification you wont have any biofilm anymore

- Compulsory: young animals
- We advise : during all the life

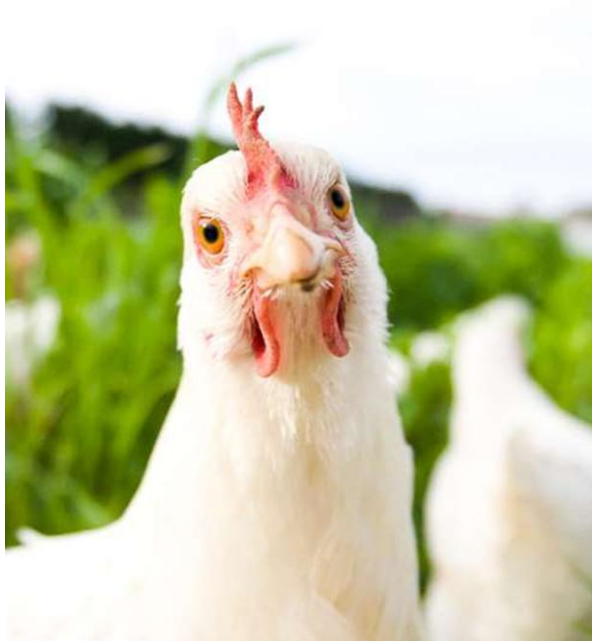
- Objectives:
- Control the pathogens
- Activate pepsin and pepsinogen
- Improve digestibility
- Help feed transition

High hardness / High pH : 0,1 to 0,2% in weight in drinking water

Low hardness / Normal pH: 0,05 to 0,1% in weight in drinking water

Advantages for monogastric

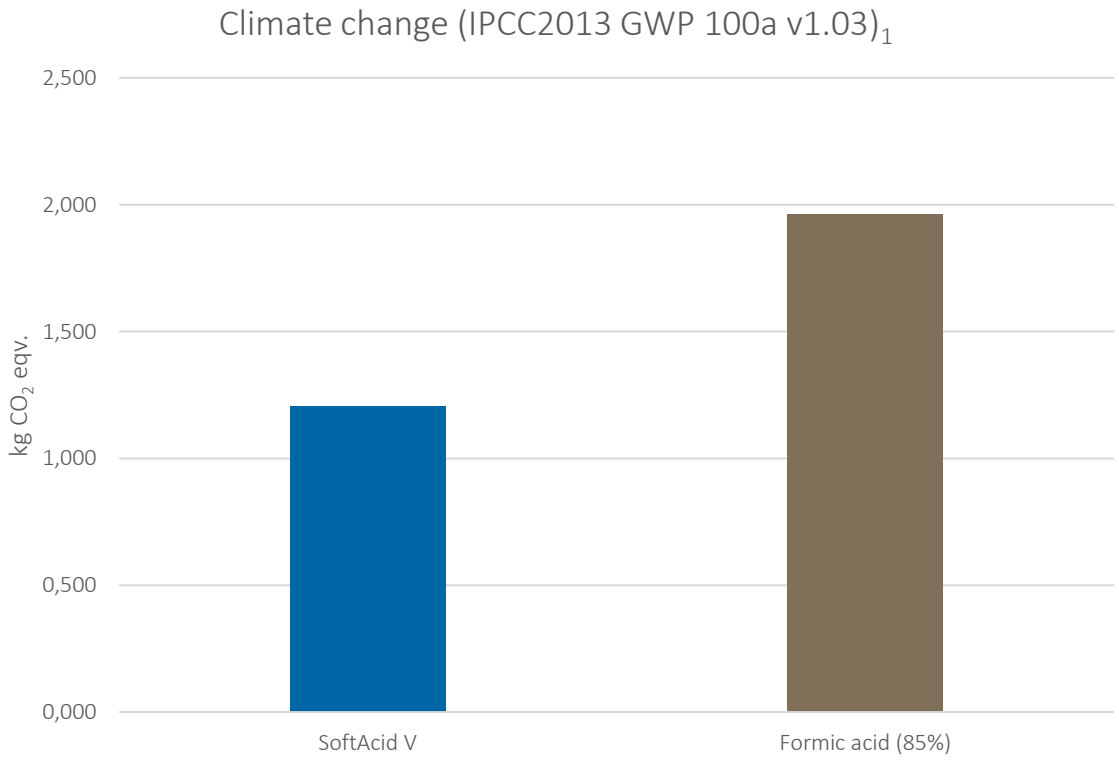
- Strong pH effect
- Removes and prevents reinfection of harmful bacteria • Prevents mould degradation of moist feeds
- Reduced smell to avoid a drop in feed consumption
- Good digestibility effect



- UNIQUE HEALTH AND SAFETY CHARACTERISTICS
- Less corrosive than other acids
- Less evaporation of acidic fumes

All of these benefits can be achieved without the same level of handling seen with other acid based preservatives

Sustainability - SoftAcid



Did you know?

By replacing formic acid with SoftAcid V, you reduce your CO_2 emissions by 38%

If the pig feed in Norway per year was produced with SoftAcid V instead of formic acid, CO_2 emissions are reduced equivalent to the emissions of 576 cars per year$_2$ or 2 689 flights from London to New York and back$_3$.