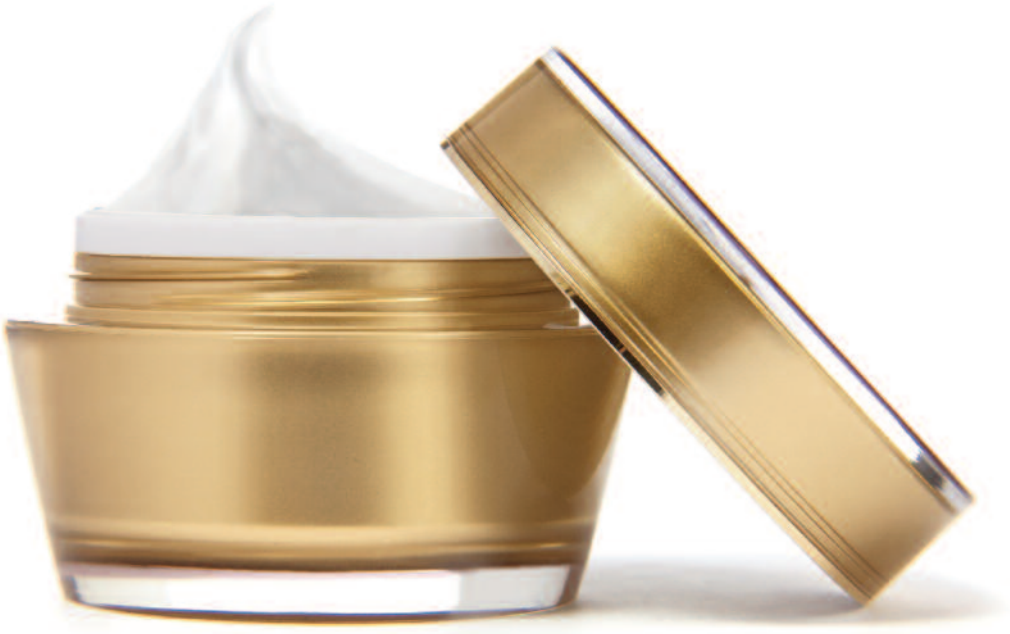
Jungbunzlauer

From nature to ingredients®

facts

Bio-based preservation support with Zinc Lactate and Lactic Acid



Introduction

In the cosmetics world there is an increasing demand for products that contain natural ingredients rather than potentially harsh chemicals. Recently, the preservatives used to inhibit the growth of microorganisms and thus extend shelf-life have caught the attention of consumers, especially in the field of leave-on cosmetics such as face creams and body lotions. Health concerns and a negative perception of some preservative groups have led to a growing trend towards self-preserving cosmetic formulations bearing “preservative-free” claims. However, these products still need to be safe to use, so reducing preservative content presents a considerable challenge for product developers.

Getting more out of ingredients: multifunctionalism

Until recently, parabens were the preservatives of choice for cosmetic products. These esters of 4-hydroxybenzoic acid are efficient against a broad spectrum of microorganisms and exhibit good solubility, no odour, temperature stability and antimicrobial activity in a broad range of pH.[1] Unfortunately they have recently come under suspicion of having a negative effect on human health. Although parabens with a short alkyl chain are still permitted for use under the European cosmetic regulation (Regulation (EC) No 1223/2009), some parabens are classified as endocrine disrupting chemicals that may eventually lead to hormone-related health effects.[1,2] Other groups of conventional preservatives include isothiazolinones and formaldehyde releasers. While these are indeed effective preservatives when used in cosmetic formulations, both have been known to cause allergic reactions.[1,2]

So how can manufacturers avoid such ingredients and meet the demand for products without conventional preservatives or preservative-free products without compromising on product safety and stability?

The claim “preservative free” is used to indicate the absence of substances classified as preservatives according to Annex V of the European cosmetic regulation. In fact a more suitable term is “self-preserving”. Self-preserving formulations often incorporate multifunctional cosmetic ingredients as a way to improve product stability and consumer safety. Besides their main function such ingredients are able to deliver antimicrobial properties (alone or in combination with other ingredients) that could substitute for those of conventional preservatives.[2] Promising multifunctional cosmetic ingredients with known antimicrobial properties include zinc salts, lactic acid and lactates.

The use of zinc in skin care

Zinc plays an important role in many different biological processes and is a cofactor for over 1000 enzymatic reactions in the human body. Elemental zinc and its salts have been used for a long time in topical preparations for therapeutic purposes and offer a variety of benefits. Zinc compounds have proved beneficial in the treatment of skin disorders including inflammatory conditions like *acne vulgaris*, *rosacea* and *eczemas*, and their anti-inflammatory and wound-healing properties have been confirmed in many different studies.[3–5] Zinc salts are popular ingredients for daily-use skin care products, too, because of their skin conditioning and soothing effects. According to Innova Market Insights, approx. 10% of new launches of skin care products worldwide contain zinc sources.

Besides the properties mentioned above, zinc salts are also known to have an antimicrobial effect. The antimicrobial activity depends on the concentration of Zn^{2+} ions. The optimal Zn^{2+} concentration in microbial cells ranges from 10^{-7} to 10^{-5} M, depending on the microbial strain. Concentrations above 10^{-4} M in microbial cells disturb the Zn^{2+} homeostasis and cause destabilisation and enhanced permeability of the cell membrane, leading to the death of the microbial cells.[6,7] This effect not only contributes to the treatment of conditions triggered by microorganisms on the skin, it can also work as a preservative booster in a cosmetic formulation.

The functionality profile of zinc compounds in personal care formulations varies depending on the particular zinc salt. It depends not only on physical factors such as solubility or pH value but also on the properties of the respective anion, which may enhance the functionality profile.[6]

Zinc Lactate

Zinc lactate is the zinc salt of lactic acid and therefore combines the benefits of zinc ions and those of lactates in cosmetic formulations. Due to its antimicrobial properties and its ability to reduce the formation of dental plaque, zinc lactate is often used in oral care products. As a safe ingredient it is also established in the food and beverages industry as well as in skin care products. The antimicrobial properties of zinc lactate in cosmetic products have been substantiated in various studies which should support its use in self-preserving cream formulations.[2] As a multifunctional ingredient, zinc lactate offers also skin-soothing and anti-inflammatory benefits. Zinc lactate is a white odourless powder with a high solubility of 55 g/L in water (equivalent to 12.7 g zinc per L) and is Cosmos approved by Ecocert for use in cosmetic formulations.

Lactic Acid

L(+)-lactic acid is a well-known ingredient for personal care formulations. The acid serves to adjust the pH or to act as an exfoliating agent. Its salts, in particular sodium and potassium lactate, are excellent humectants and moisturisers.[8] They are part of the natural moisturising factor and therefore naturally present in skin cells. Both lactic acid and lactates are known for their antimicrobial and bacteriostatic properties, which are exploited in various industries, including home care, personal hygiene and food processing. Hence lactic acid is a promising candidate to keep cosmetic formulations stable and support their long-term preservation while adding the above-mentioned benefits. Furthermore, because they are produced using a fermentation process, lactic acid and lactates are compatible with natural cosmetic standards such as Ecocert/Cosmos.

Investigating the preserving properties of zinc salts and lactic acid

It was therefore decided to assess the ability of Jungbunzlauer's zinc salts and lactic acid to support the preservation of a skin cream. The ingredients were incorporated into cream formulations and assessed for their efficacy in preserving the formulation based on the tests described below.

The microbial stability of personal care products was tested according to European Pharmacopeia (Ph. Eur.) 5.1.3., which was originally designed to test topical cosmetic or pharmaceutical preparations.[9] This norm determines how to test the preservation efficacy of preservative systems. The test sample was inoculated with five selected microorganisms: *Pseudomonas aeruginosa* (gram-negative bacillus), *Escherichia coli* (gram-negative bacillus) and *Staphylococcus aureus* (gram-positive coccus) were tested as representatives for bacteria; *Candida albicans* (yeast) and *Aspergillus brasiliensis* (mould) represented the fungal microorganisms.

The cosmetic products to be tested were inoculated with an initial concentration of 10^5 to 10^6 colony-forming units (CFU) per mL of each microorganism. Afterwards the samples were stored at 20–25°C, protected from light. After certain time intervals (2, 7, 14 and 28 days), the concentrations of CFU/mL were investigated.

To pass the test there must be a reduction of microorganisms (log reduction) and no re-growth over time. The observed decay of microorganisms and the (non-)occurrence of growth sets the criterion A or criterion B needed to pass the test. The criteria for evaluation of antimicrobial activity are given in table 1.

Criterion A is difficult to achieve for gentle formulations, which can be claimed as preservative free at a slightly acidic pH. The log reduction required for criterion B is either lower than criterion A or can be achieved at a later point in time. The test is failed if neither criterion A nor criterion B is reached.

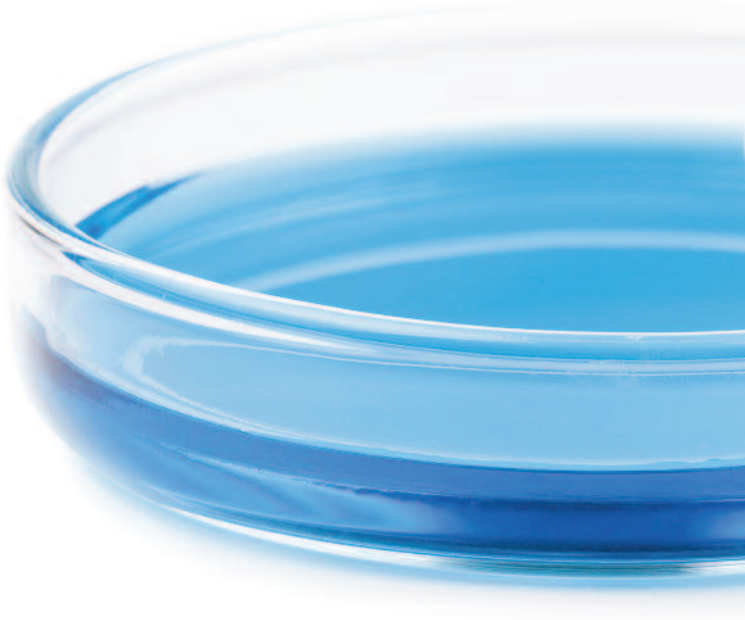


Table 1: Criteria of acceptance for Ph. Eur. 5.1.3. test

	Test criteria	Log reduction			
		2 d	7 d	14 d	28 d
Bacteria	A	2	3	-	NI
	B	-	-	3	NI
Fungi	A	-	-	2	NI
	B	-	-	1	NI

NI: no increase in number of viable microorganisms compared to the previous reading

Results and discussion

An oil-in-water cream formulation was developed to evaluate the preservation performance of zinc salts and lactic acid. It was kept very simple, with a conventional aqueous phase consisting of water, glycerine as moisturiser and xanthan gum as thickener. The oil phase included an emulsifier, a co-emulsifier and two emollients. The antimicrobial substances tested were zinc citrate, zinc gluconate and zinc lactate, plus lactic acid in combination with anisic acid and caprylic acid as boosters. The formulation is displayed in table 2.

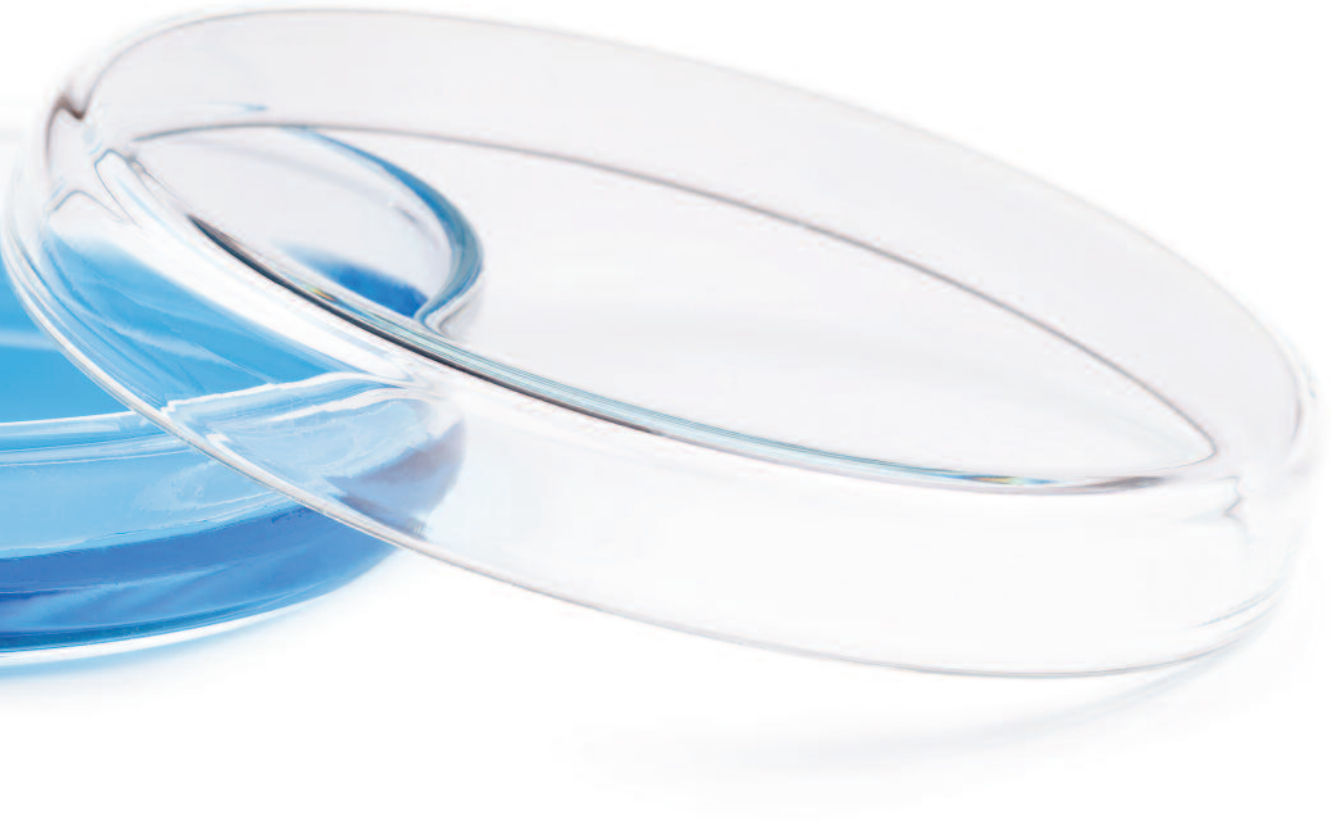


Table 2: Composition of cream formulation

Phase	Name	INCI	Function	Supplier	Cream formulation with zinc lactate %	Cream formulation with lactic acid %
A	Water demin.	Aqua	Solubiliser		q.s. to 100	q.s. to 100
	Glycerine	Glycerine	Moisturiser		3.0%	3.0%
	Xanthan Gum FNCSP-PC	Xanthan Gum	Thickener	**Jungbunzlauer**	0.4%	0.4%
B	Axol® C 62 Pellets	Glyceryl Stearate Citrate	Emulsifier	Evonik	4.0%	4.0%
	Lanette® O	Cetearyl Alcohol	Co-Emulsifier	BASF	1.0%	1.0%
	Dermofeel® Sensolv	Isoamyl Laurate	Emollient	Evonik	4.0%	4.0%
	Tegosoft® AC MB	Isoamyl Cocoate	Emollient	Evonik	4.0%	4.0%
C	Zinc Salt*		Antimicrobial substance	**Jungbunzlauer**	1.0%	-
	Lactic Acid 90% heat stable, Personal Care Grade	Lactic Acid		**Jungbunzlauer**	q.s.**	3.2%
	Booster***				-	0.2-0.4%

*The following zinc salts were tested in the formulation: zinc citrate, zinc gluconate and zinc lactate.
** Lactic acid is used for pH adjustment.
***The boosters 0.2% anisic acid and 0.4% caprylic acid were tested in combination with lactic acid.

First, the cream formulation was analysed without an antimicrobial ingredient (blank). For zinc salt screening each zinc salt was tested at a concentration level of 1% at a pH of 5.5. The results are shown in table 3.

The blank formulation failed for all tested germs. After adding the anti-microbial substances, all formulations showed improved preservation efficacy. The formulations with zinc citrate and zinc gluconate were shown to be effective against *E. coli*, *S. aureus* and *C. albicans*.

As expected, the formulation with zinc lactate showed the best preservation efficacy. It was the only one of the tested zinc salts to show efficacy against *P. aeruginosa*. Additionally the preservation efficacy was increased for *E. coli*. In respect of both these microorganisms the formulations with zinc lactate passed the test for criterion A. However, at a pH of 5.5 the zinc lactate formulation did fail against *A. brasiliensis*. A further trial was therefore performed with a higher concentration (2%) of zinc lactate.

As described above, the antimicrobial properties of zinc salts depend on the concentration of Zn^{2+}, as a concentration above 10^{-4} M in the microbial cells is needed to perturb the Zn^{2+} homeostasis. Increasing the concentration did not produce the desired result and overall showed no better results than the formulation with 1% zinc lactate, leading to the conclusion that 1% zinc lactate already offered a Zn^{2+} concentration above this limit. Overall, no tested formulation was effective against *A. brasiliensis*.

Table 3: Test results of cream formulation with zinc salts according to Ph. Eur. 5.1.3.

	Cream formulation – screening zinc salts pH 5.5				
Test germ	**Blank**	**1% zinc citrate**	**1% zinc gluconate**	**1% zinc lactate**	**2% zinc lactate**
E. coli	F	B	B	A	A
P. aeruginosa	F	F	F	A	A
S. aureus	F	B	B	B	B
C. albicans	F	A	A	A	A
A. brasiliensis	F	F	F	F	F
Total test results	**F**	**F**	**F**	**F**	**F**

As the growth of microorganisms is strongly pH-dependent[10], further tests with 1% zinc lactate at different pH values were performed to look for effective preservation against *A. brasiliensis*. Considering that the natural skin pH ranges from slightly acidic to neutral[11], four different pH values were tested. In the first screening, the tests were done at pH 5.5 (see results in table 3). In a second step, the formulation was tested at pH 4.5, pH 5 and pH 7. The results are shown in table 4.

In general, increasing the pH value led to a reduction in preservation performance. The cream formulation with the lowest tested pH (pH 4.5) passed Ph. Eur. test criterion B.

For gentle, self-preserving formulations with a pH value between 4.5 and 5.5, it will be difficult to achieve criterion A. It can only be satisfied by using conventional preservatives. As the natural skin surface pH is on average 4.7 the pH of 4.5 is acceptable for a skin cream formulation and supports the acidic protective layer of the skin.[11]

Table 4: Test results of cream formulation with 1% zinc lactate at different pH values according to Ph. Eur. 5.1.3.

	Cream formulation with 1% zinc lactate			
Test germ	**pH 4.5**	**pH 5**	**pH 5.5**	**pH 7**
E. coli	A	A	A	A
P. aeruginosa	A	A	A	F
S. aureus	B	B	B	A
C. albicans	A	A	A	A
A. brasiliensis	B	F	F	F
Total test results	**B**	**F**	**F**	**F**

Previous studies on the biocidal properties of lactic acid[10,12,13] have already verified the preservation effect of this bio-based organic acid for aqueous solutions.

The antimicrobial effect of organic acids is based on their penetration into the microbial cell and a subsequent acidification of the cell interior, which ultimately results in cell inactivation. In this context, the dissociation of the organic acid in an aqueous environment is important. The organic acid can diffuse through the cell membrane only as an undissociated and thus uncharged molecule. The pK_a value of lactic acid is 3.9, which means that at a pH of 3.9 there is equilibrium between undissociated and dissociated lactic acid molecules. With decreasing pH, the share of undissociated acid and thus antimicrobial efficacy increases.

At higher pH, namely skin neutral pH, a part of the lactic acid molecules is dissociated, therefore negatively charged and unable to diffuse through the cell membrane.[14]
Because of this, it is necessary to add a booster or secondary active to improve the antimicrobial effect of any formulation with lactic acid.

The cream formulation shown in table 2 was analysed with 2.9% of lactic acid in combination with two boosting substances at a pH of 5.5. This combination and these concentration levels had already proved suitable for preservation of a shower gel formulation (internal data).

The results for the cream formulation with lactic acid in combination with anisic acid and caprylic acid are shown in table 5. The preservation test was passed with criterion B for both formulations. In a direct comparison, the formulation with anisic acid performed slightly better, achieving criterion A for *A. brasiliensis*.

Table 5: **Test results of cream formulation with lactic acid in combination with boosters according to Ph. Eur. 5.1.3.**

	Cream formulation with lactic acid in combination with booster, pH 5.5	
Test germ	**0.2% anisic acid**	**0.4% caprylic acid**
E. coli	B	B
P. aeruginosa	A	A
S. aureus	B	B
C. albicans	A	A
A. brasiliensis	A	B
Total test results	**B**	**B**

Both tested combinations proved to be effective against microbial spoilage and can be used to support self-preserving or preservative-free claims.

Summary

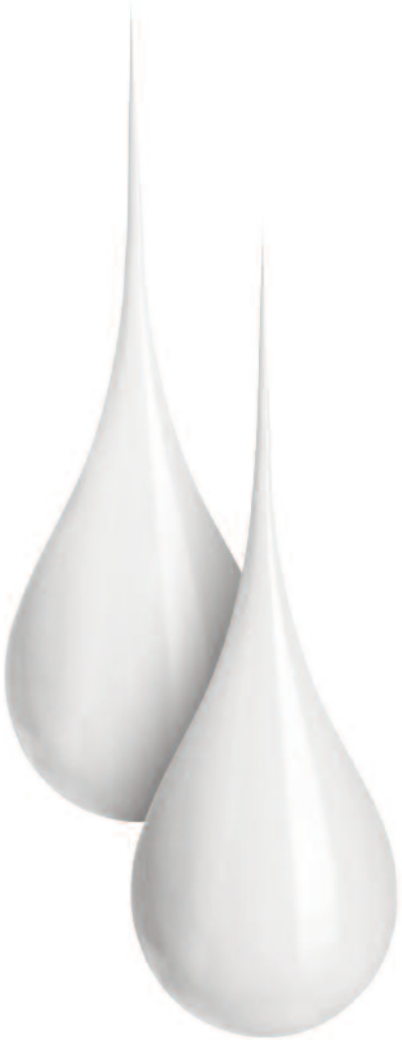
The preservation efficacy of Jungbunzlauer ingredients in a cream formulation was tested by means of the well-established Ph. Eur. test 5.1.3. and proved that zinc lactate and lactic acid show biocidal activity. These multifunctional ingredients can offer preservation support in skin care product formulations which avoid or reduce the use of conventional preservatives.

Zinc lactate has the added benefit of skin-soothing and anti-inflammatory properties, combining the benefits of zinc and lactate ions.

For cream formulations with higher pH values, we recommend lactic acid as a zinc-free solution. Lactic acid and lactates have the added benefits of humectant and moisturising properties and are naturally present in human cells. In combination with boosting substances they offer good preservation support.

Hence zinc lactate and lactic acid from Jungbunzlauer, which are both Cosmos approved by Ecocert, demonstrate multifunctional activities that enable the formulation of skin creams with a cleaner label and shorter ingredient list.

Approved by ECOCERT RAW MATERIAL
COSMOS APPROVED



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About Jungbunzlauer

Jungbunzlauer is one of the world's leading producers of biodegradable ingredients of natural origin. We enable our customers to manufacture healthier, safer, tastier and more sustainable products. Thanks to continuous investment, state-of-the-art manufacturing processes and comprehensive quality management, we are able to provide outstanding product quality.

Our mission "From nature to ingredients®" commits us to protecting people and their environment.

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