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Taste and flavour modulation with organic acids in sugar confectionery

Jungbunzlauer

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Introduction

Sugar confectionery products, like hard boiled or gummy candies, represent a big share of the total confectionery market. Candies are popular around the world and hugely diverse in shape, texture, colour and flavour. Basic formulations can be adjusted relatively easily to take account of specific preferences in different regions.

The main component of classic formulations, of course, is sucrose. However, as candies are increasingly a target for sugar reduction exercises, polyols, such as isomalt, would be the main ingredient then. Flavour is then added to give the candy the desired taste. But in order to create a well-balanced, delicious product, one more ingredient is essential. For a rounded, optimised taste profile an organic acid is needed to counteract the sweetness. Traditionally citric acid has been the acidulant of choice in the sugar confectionery industry. But acids do not simply provide sourness. Depending on the type of acid and its individual taste characteristics, it will influence the whole taste profile of the final product. The interaction of flavour, sweetener and acid defines the flavour profile.

Taste and taste profiling is generally very important in the food industry, especially when it comes to off-taste and off-taste masking. In reformulations to reduce the amount of sugar, taste deviations and even off-taste notes may occur. Here, organic acids can help achieve and preserve the desired flavour.

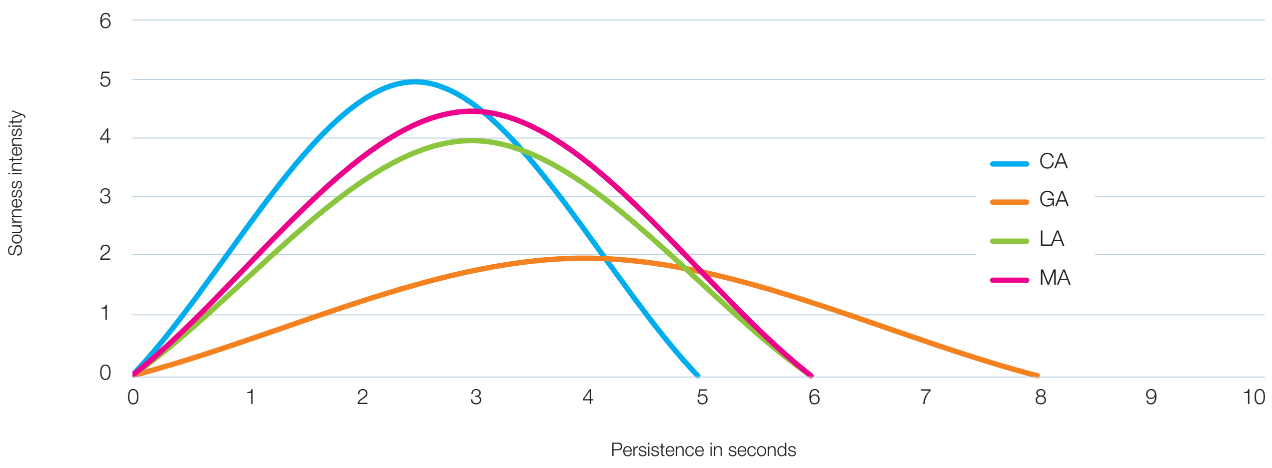
This paper will give an overview of different sensory aspects of organic acids in confectionery products. It will provide ideas on how to create a balanced formulation and how to modulate a flavour using different acids and acid combinations. In particular, it will report on an extensive sensory study conducted to evaluate the ability of organic acids to modulate flavours.

Acid/sweetness balance for a harmonious taste impression

Human beings are able to perceive five basic tastes: sweet, sour, salty, bitter and umami. In confectionery, sweet and sour play the most important role. Initially, confectionery products should impart sweetness. However, for a rounded taste impression an acidic component is needed, and it is crucial to achieve a good balance between these two basic ingredients.

All organic acids show a specific acidity profile. Figure 1 shows the sour taste intensity and persistence of citric acid, lactic acid, gluconic acid and malic acid in aqueous solution.

Figure 1: Persistence and intensity of citric acid (CA), gluconic acid (GA), lactic acid (LA) and malic acid (MA) sourness in 0.18% aqueous solution

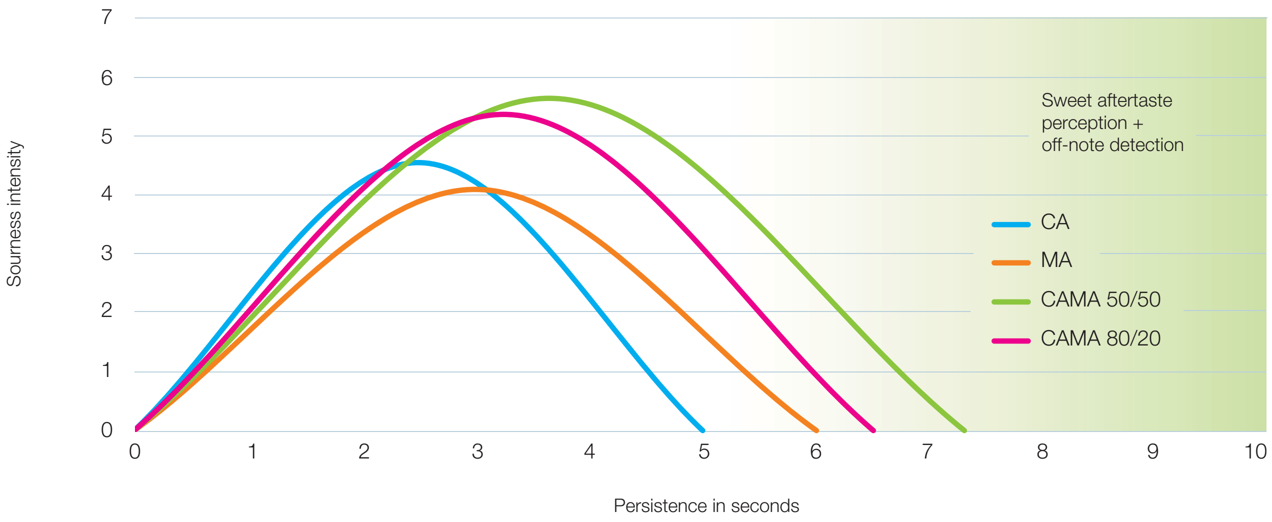


Citric acid provides a quite intense sour impression which disappears after a short time. In contrast, gluconic acid has only approximately one third of the sour taste intensity of citric acid but the sour taste impression is longer lasting. Malic acid and lactic acid are somewhere in between the two, showing comparable sour taste intensities and persistence.

Citric acid is often used for acidification in sugar-based products. The combination works well, because the time-intensity curves for the two components are almost identical, i.e. the sweet and sour tastes reach their maximum almost simultaneously. Replacing sugar with high intensity sweeteners (HIS) usually results in a typically sweet aftertaste and off-note detection which outlasts the sourness of citric acid. Therefore a combination of citric acid and malic acid is often used to cover the persisting sweetness of HIS.

In combination these two acids display a synergy in sourness intensity and persistence resulting in a rebalanced acid/sweetness perception in HIS sweetened products. Figure 2 demonstrates the sourness intensity and persistence of citric acid and malic acid used as single acidulants, as compared with combinations of the two. Citric acid has a slightly greater sourness intensity than malic acid but the sourness does not last as long. Both acids correspond quite well with the sweetness perception time associated with sugar, but the typical sweet aftertaste of HIS cannot be covered using either of these acids alone. However, in combination the two acids synergistically prolong the perception of sourness and therefore compensate the sweet aftertaste (indicated by the greenish background).

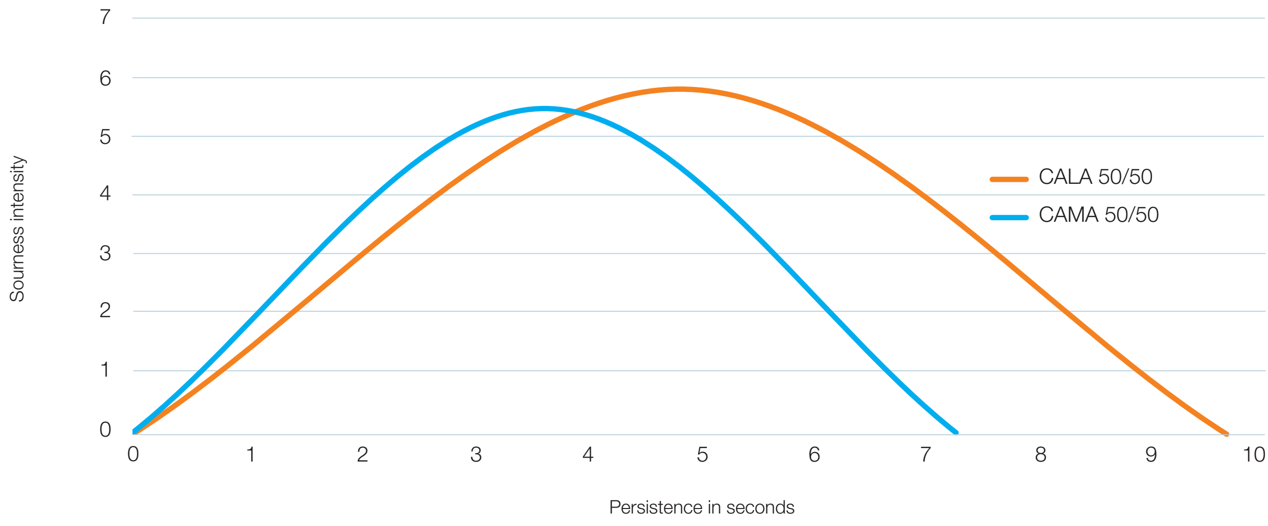
Figure 2: Sourness persistence and intensity of citric acid (CA), malic acid (MA) and combinations thereof compared to duration of sweetness perception



Lactic acid in combination with citric acid shows an even stronger synergistic effect in terms of sourness intensity and persistence. In figure 3 the acidic taste profile of a 50/50 mixture of citric acid/lactic acid is plotted against a citric acid/malic acid mixture of the same ratio. In total the acidic taste intensity of the citric acid/lactic acid combination is slightly higher and the acidic taste is clearly prolonged compared to the combination containing malic acid. Hence the sweet aftertaste and other off-notes are better compensated. This combination therefore represents a feasible alternative to malic acid.

Both citric acid and lactic acid manufacturing processes are based on fermentation. This is a clear advantage when it comes to consumer desires for more natural ingredients. Malic acid, in contrast, is a synthetic product made from petrochemical raw materials. Citric acid and lactic acid are therefore clearly preferable.

Figure 3: Sourness persistence and intensities of 50:50 combinations of citric acid (CA) with either malic acid (MA) or lactic acid (LA)



Descriptive Sensory Study: Taste modulation in hard boiled candy

In the quest for a particular taste a broad range of different flavour types with many variations are available to confectionery manufacturers. It may take a long time until the perfect match is found, but often just a slight adjustment to the basic formula provides the desired finishing touch.

A descriptive sensory study was designed to demonstrate the effect of different acids and combinations thereof on overall taste in sugar confectionery products. An expert panel examined a test matrix representative of sugar-free candies in a conventional sensory profile (DIN ESN ISO 13299). The test matrix, a 30% solution of previously cooked and then dissolved sugar-free candies with different acid combinations, was chosen to reduce signs of fatigue that may arise among panellists eating candies.

Of interest were eleven acid combinations composed of binary mixtures of 50% citric, lactic, gluconic, malic and phosphoric acid solutions in different ratios. These were tested in two natural flavours especially suited for confectionery applications: strawberry *(creamy, ripe, juicy)*, representative for berry flavours, and orange *(fresh, zesty)* for citrus.
In the hard boiled candy formulation the acid dosage for both flavours was 1.5% except for the combination of citric acid/gluconic acid (ratio 50:50) where it was 2% (figure 4). The 30% test solutions were prepared freshly before each tasting session and all samples were served 3-digit-coded, randomised, at room temperature (21°C) and covered with lids in order to preserve headspace for aroma evaluation.

Figure 4: Recipe for strawberry-flavoured hard boiled candies, which were dissolved to a 30% test solution for the sensory evaluation

Recipe sugar free hard boiled candy

	Ingredient	Details	%	% acid
1	Isomalt		75.00	
2	Reb A 97		0.13	
3	Water		22.32	
4	Natural flavour	strawberry (Döhler 813553)	1.00	
5	Colour		a.d.	
6	Acid (50%)	acid(s) + ratio		
		CA 100	x	1.50
		LA 100	x	1.50
		CAMA 50/50	x	1.50
		CALA 80/20	x	1.50
		CALA 50/50	x	1.50
		CALA 20/80	x	1.50
		LAGA 80/20	x	1.50
		CAGA 80/20	x	1.50
		CAGA 50/50	x	2.00
		PA 100	x	1.50
		PACA 50/50	x	1.50
		Total	**100.00**	

Instructions: Mix ingredients 1 + 3 and heat up to 165°C in order to evaporate water (residual moisture 3%). Cool down to 145°C and wait until air bubbles have disappeared. Add residual ingredients and stir well. Pour into silicon moulds and let set for approx. 20 hours.

For preparing the 30% test solution: Crush candies and weigh in required sample quantity. Fill up with water (Black Forest) and stir until the candy is completely dissolved.

Eight trained panellists initially characterised the samples with relevant and objective sensory attributes (from the categories odour, basic taste, flavour and mouthfeel) and subsequently rated the perceived intensity of each descriptor on a 7-point-scale.

Figure 5 lists all analysed attributes for strawberry flavour with their respective significances. The only attribute for which the test samples were not significantly differentiated was odour. In every other category, particularly in flavour attributes, modifications were perceived.

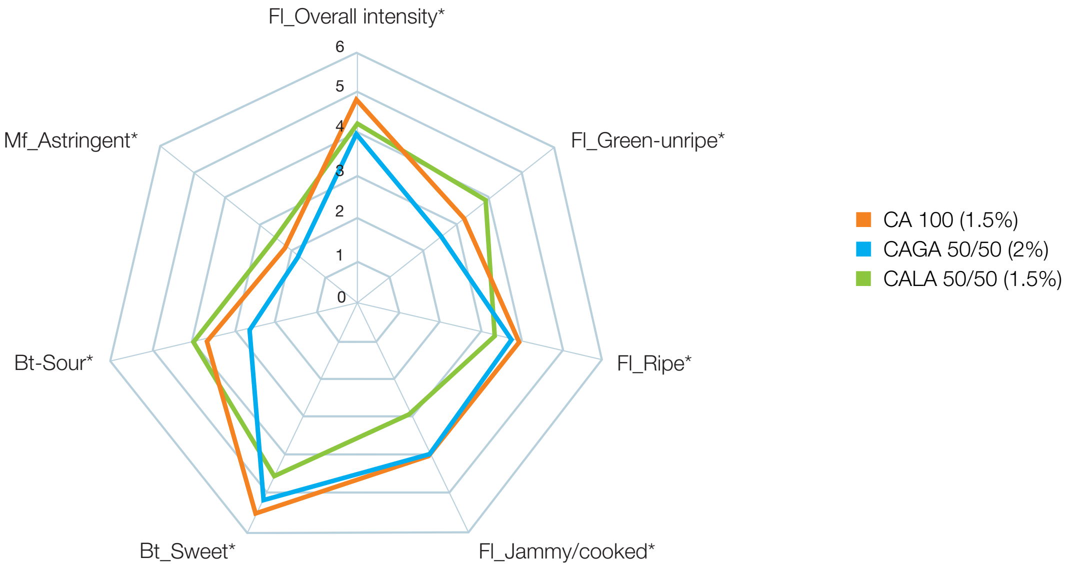
Consequently, the results of this study provide reasonable evidence that changing the acidulants significantly influences the overall taste of strawberry-flavoured hard boiled candies and thus gives every end product a distinctive character.

Figure 5: Results of ANOVA ($\alpha = 0.05$) displaying descriptors analysed with respective levels of significance for all samples

	Descriptor	Level of significance
Odour	Overall intensity	n. s.
	Green-unripe	n. s.
	Ripe	n. s.
Flavour	Overall intensity	***
	Green-unripe	***
	Ripe	***
	Jammy/cooked	***
Basic taste	Sweet	*
	Sour	***
Mouthfeel	Astringent	*

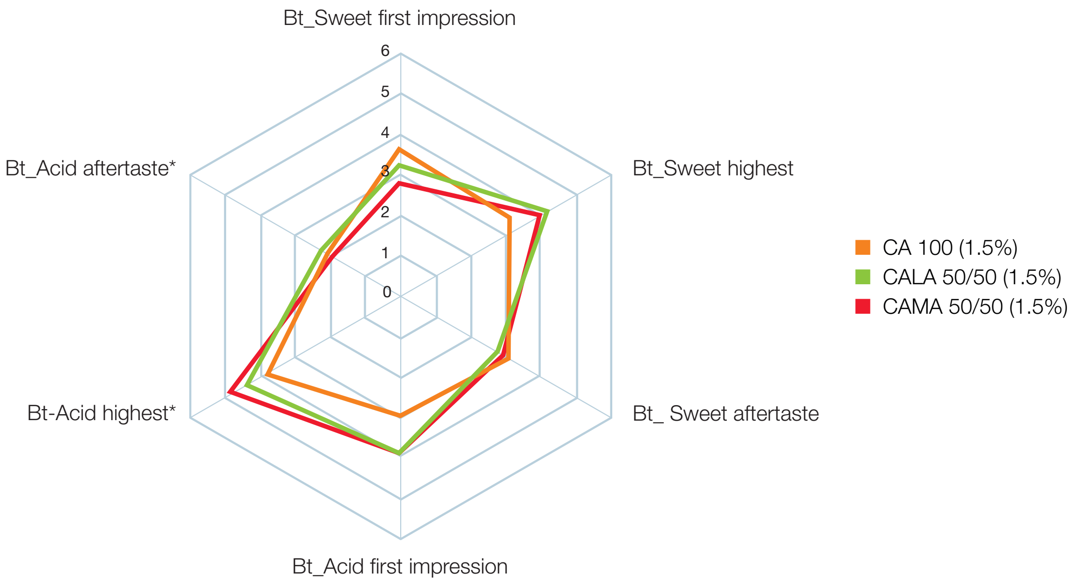
For example, compare the sensory profile of pure citric acid (CA 100) against its combinations with lactic acid (CALA 50/50) and the relatively mild gluconic acid (CAGA 50/50) (figure 6): replacing half of the citric acid can either emphasise (lactic acid) or suppress (gluconic acid) the greenish-unripe tones of the strawberry flavour. While gluconic acid also reduces sourness and astringency, it maintains the jammy/cooked and ripe tone of citric acid alone. The addition of lactic acid emphasises green-unripe flavours by increasing sourness and astringency while reducing ripe and jammy/cooked flavours.

Figure 6: Sensory profile of sugar-free strawberry-flavoured candy solutions acidified with 50% solutions of pure citric acid versus its combinations with lactic acid or gluconic acid (ratio 50/50). Significant differences (α= 0.05) are marked* when they occurred between at least two combinations.



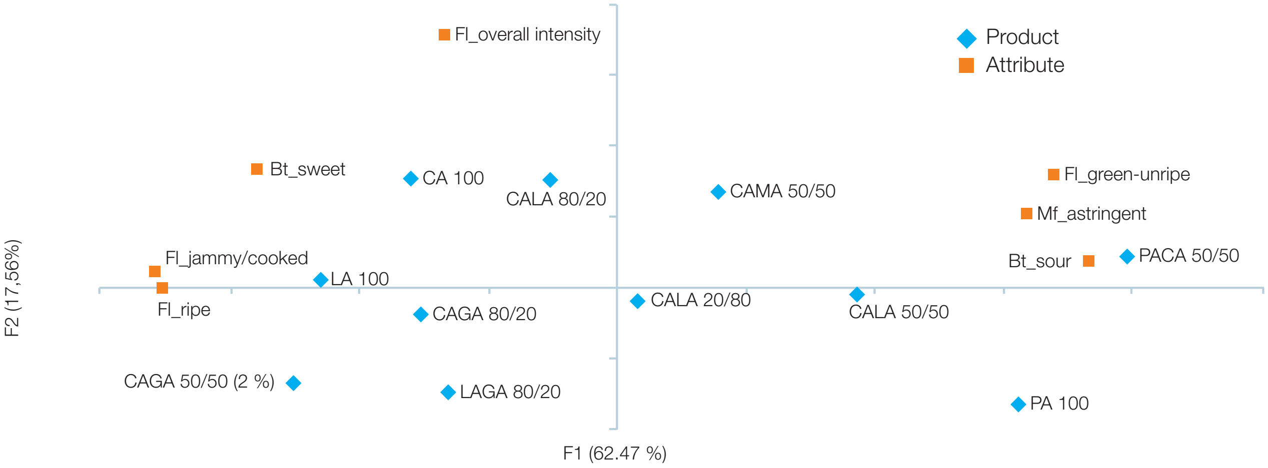
An example which indicates rather the opposite, namely the exchangeability of one acidulant with another, is shown in figure 7. This figure is based on the results of the orange flavour evaluation and compares citric acid alone (CA 100) to the common combination of citric acid with malic acid (CAMA 50/50) or with lactic acid (CALA 50/50) already described above. The only significant differences found were for the highest acid perception. Overall the picture clearly indicates that the acid/sweetness profile of CALA 50/50 is equivalent to that of CAMA 50/50. Taking citric acid alone as baseline, the lactic acid combination is close to or even matches the malic acid combination. Both combinations influenced sour (increase) and sweet (decrease) taste in the same direction and to a comparable extent.

Figure 7: Sweetness and acidity profiles for first, highest and latest impressions resulting from addition of 50% solutions of pure citric acid versus combinations with malic acid or lactic acid (ratio 50/50) in orange-flavoured candy-solutions. Significant differences (α= 0.05) are marked* when they occurred between at least two combinations.



The principal component analysis (PCA) plot of the strawberry flavour evaluation in figure 8 is a graphical representation of the interrelationships between the descriptors and the products tested. The further to the left a product is found, the more pronounced are the attributes *sweet, ripe* and *jammy/cooked*. Products on the right-hand side are characteri by more *sour, green-unripe* and astringent notes. *Overall flavour intensity* is greater the higher the sample is located in the diagram. Products grouped close together are perceptually more similar to each other and thus more exchangeable than products grouped further from one another.

Figure 8: Principal Component Analysis (PCA) illustrating correlations in the whole data set. 80.03% of the total variance can be explained by the two first principal components (F1 and F2)



Pure lactic acid (LA 100) demonstrates the challenge of predicting in which direction a certain acid will influence a flavour: Whereas in combinations with citric acid, lactic acid tends to emphasise the attribute green/unripe, on its own it makes the flavour riper and sweeter.

Conclusion

In order to get the most out of a sugar confectionery product, it is above all important to achieve a good balance between acidity and sweetness. The acids and sweeteners used therefore need to fit together in terms of persistence and intensity profile. The profile of citric acid matches perfectly to the sweetness of sugar. However, imbalances occur as soon as the sugar is replaced by other substances, e.g. high intensity sweeteners. Here, optimised acid combinations can help to cover lingering sweetness or even off-tastes. Some acid combinations show synergistic effects. Consequently, a large variety of acid types is available for use.

Different acidulants can influence the flavour characteristics of sugar confectionery beyond adjusting acidity and sweetness. The sensory profiling of a strawberry- or orange-flavoured sugar-free hard boiled candy formulation demonstrates that different acid combinations modulate the original flavour in different directions. This knowledge provides some flexibility to product developers in emphasising specific flavour notes. Hence, it is possible to reduce the sweet impression while increasing the unripe notes of a certain flavour just by exchanging one acid component for another or by changing the ratio of an acid combination. Conversely, some acids can be exchanged for others with only a minor influence on the taste profile of the formulation. This can be advantageous in terms of cost savings or if more natural solutions are required.

The sensory results presented are based on specific types of strawberry and orange flavours. It is expected that similar results can be achieved using other flavour types as well, but specific tests would be required to determine the flavour-modulating effect of different acids and their combinations on a case by case basis. However, this study already provides a good guide as to how to use acids in a more sophisticated way and how to improve the overall taste of a sugar confectionery product with only small adjustments.

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The Authors

Katharina Pletsch – Project Manager Application Technology, Jungbunzlauer Ladenburg GmbH
katharina.pletsch@jungbunzlauer.com

Frithjof Raab – Technical Service Manager, Jungbunzlauer International AG
frithjof.raab@jungbunzlauer.com

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Headquarters **Jungbunzlauer Suisse AG** · CH-4002 Basel · Switzerland · Phone +41-61-2955 100 · headquarters@jungbunzlauer.com

www.jungbunzlauer.com

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