Acidifying Sauces & Dressings without Compromising Taste

Presented by:

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INTRODUCTION

Sauces and dressings cover as different products as pasta sauces and other cooking sauces, salad dressings and mayonnaise, table sauces and dips. Sauces and dressings is a big market with an annual global consumption of 30 million tons, representing a total spent of 65 billion USD.

As convenience has become key in the eating habits of many consumers, sauces and dressings as well as foods incorporating them like prepared salads, sandwich fillers and canned, chilled or frozen ready meals gained huge popularity, entertaining market growth and innovation, especially in flavour and packaging. Consumers however no longer accept to compromise quality, safety or healthiness for convenience. That is a real challenge for producers of sauces and dressings as all requirements are not easily compatible. For example, synthetic preservatives increase the safety of sauces and dressings, but consumers reject them increasingly as they are not natural and thus somehow considered as unhealthy. Producers have other means to preserve sauces and dressings like heat-treatment and acidification. However heat treatment is not possible for all types of those products and it is often associated with changes in taste and loss of nutritional properties, thus with lower quality and healthiness. Acidification can also have a negative impact on taste.

Safety concerns of consumers are also reflected in the development of natural and organic sauces and dressings, while rising health consciousness pushes consumers towards reducing their fat, sugar and salt intake. As regular dressings and mayonnaise are rich in fat, low fat and low calorie versions thereof are already appreciated, while low sugar and low sodium sauces start getting momentum.

Producers of sauces and dressings can find at Jungbunzlauer the solutions to make high quality products which taste good, which are safe and which are healthy:

- acidification without compromise on taste with gluconic acid and glucono-delta-lactone
- preservative-free preservation with sodium diacetate
- dry and concentrated vinegar flavour with ESSICCUM®
- excellent stability with special grades of xanthan gum
- natural sugar and calorie reduction with erythritol
- simple and tasteful sodium reduction with sub4salt®

While this paper is focused on acidifying sauces and dressings without compromising taste thanks to gluconic acid and glucono-delta-lactone, more information on the other Jungbunzlauer solutions for better, safer and healthier sauces and dressings is available on request.

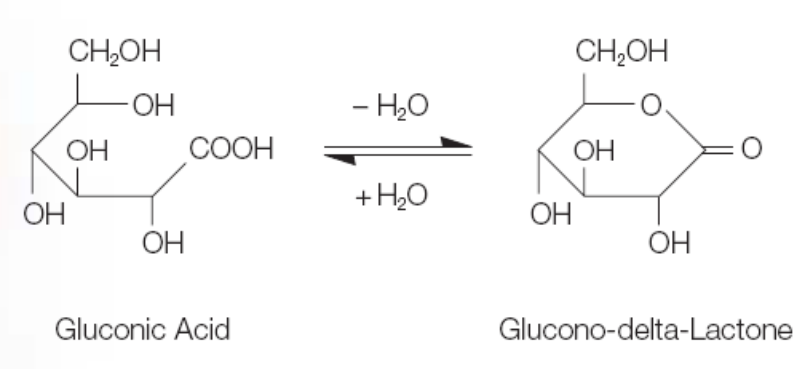
WHAT ARE GLUCONIC ACID AND GLUCONO-DELTA-LACTONE?

Vinegar and lemon juice are automatically associated with acidity, tradition and naturalness in the mind of almost every individual. Because the name citric acid is associated with citrus fruit and, and because citric acid is widely used in food and beverages since decades, consumers' acceptance is high. The same goes for lactic acid whose name is associated with milk and its healthy image. To a lesser extent already, tartaric acid is associated with wine. And even to a lesser extent, consumers know that acetic acid is nothing else than the acid component of vinegar, and that malic acid is the main acid component in apples. So what to say about gluconic acid? In fact, almost nobody except some chemists, food technologists and apitherapy specialists knows that gluconic acid is the main acid component in honey and in royal jelly, occurring in those products in concentrations up to 1%. Also fermented drinks like wine, kombucha and Bionade® contain gluconic acid naturally in concentrations up to 1%.

In fact gluconic acid shall simply be associated with glucose because it is nothing else than a molecule of glucose in which the aldehyde function has just been oxidated to an acid function. In bee products an enzyme transforms glucose into gluconic acid and in fermented drinks the job is done by microorganisms.

Glucono-delta-lactone (GdL) is the dry form of gluconic acid obtained by removal of water during crystallisation (Fig. 1). When GdL is dissolved in water, the reaction is reversed, resulting in a solution of gluconic acid. GdL does not exist in the solution (except under very specific conditions) and gluconic acid can not be obtained dry under normal crystallisation conditions.

Fig. 1: Reversibility between gluconic acid and GdL



ACIDS IN SAUCES AND DRESSINGS

Acids are used to decrease the pH of food. By doing so, they improve its microbial stability and impact its taste by imparting their own flavour and modifying the taste perception of other ingredients. Sometimes they are also used to chelate iron and copper ions which can catalyse food spoilage reactions like rancidity.

Salad dressings, mayonnaise and ketchup typically have a pH between 3 and 4, while cooking sauces and dips are normally in a higher pH range, between 4 and 6. To get to the desired pH level, producers have the choice between various acids. Tradition and labelling speak in favour of vinegar and lemon juice. Economics, stability of quality and of supply speak more in favour of the pure form of their acid components, i.e. acetic acid and citric acid. However, because of the sourness of vinegar / acetic acid and too a lesser extent lemon juice / citric acid, lactic acid has become widely used as a mild tasting acid component in sauces and dressings, and certain producers have already recognized that GdL and gluconic acid can bring them similar and further benefits. Tartaric and malic acids are only rarely used in sauces and dressings.

According to data extracted from Mintel GNPD, a database analysing new product launches, vinegar remains by far the most used acid in sauces and dressings, in front of citric acid, lemon juice, lactic acid and acetic acid (Fig. 2). Product launches with GdL / gluconic acid have now reached a level making them visible in statistics.

Fig. 2: Acids in sauces and dressings launches since January 2008

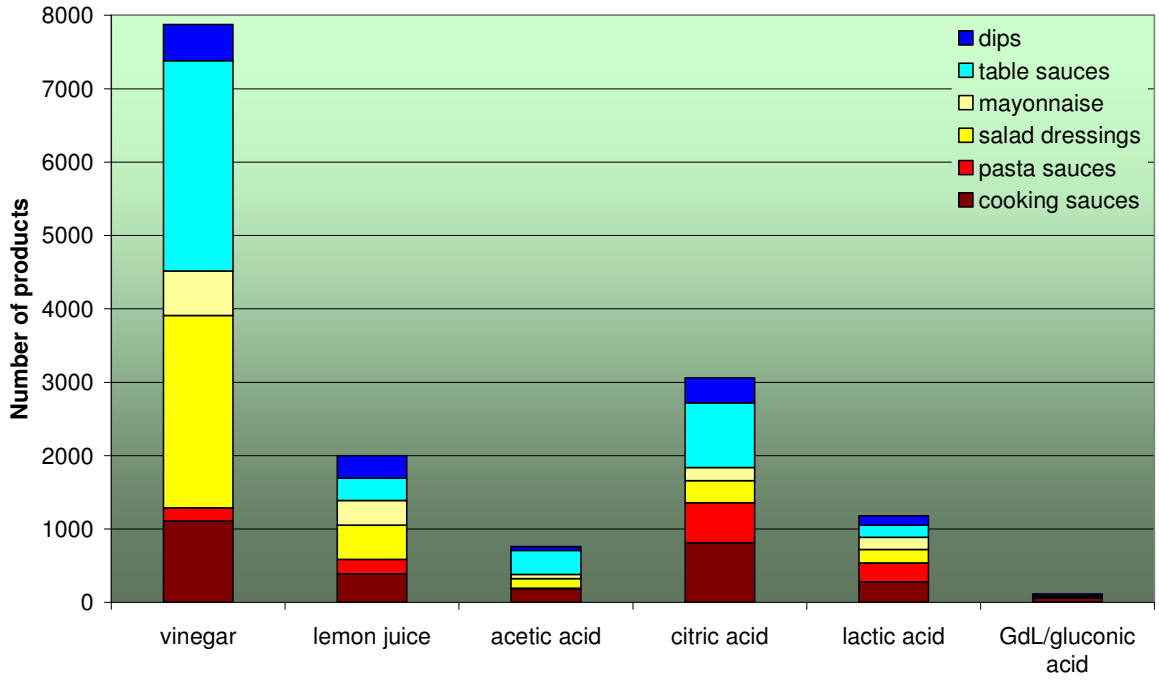
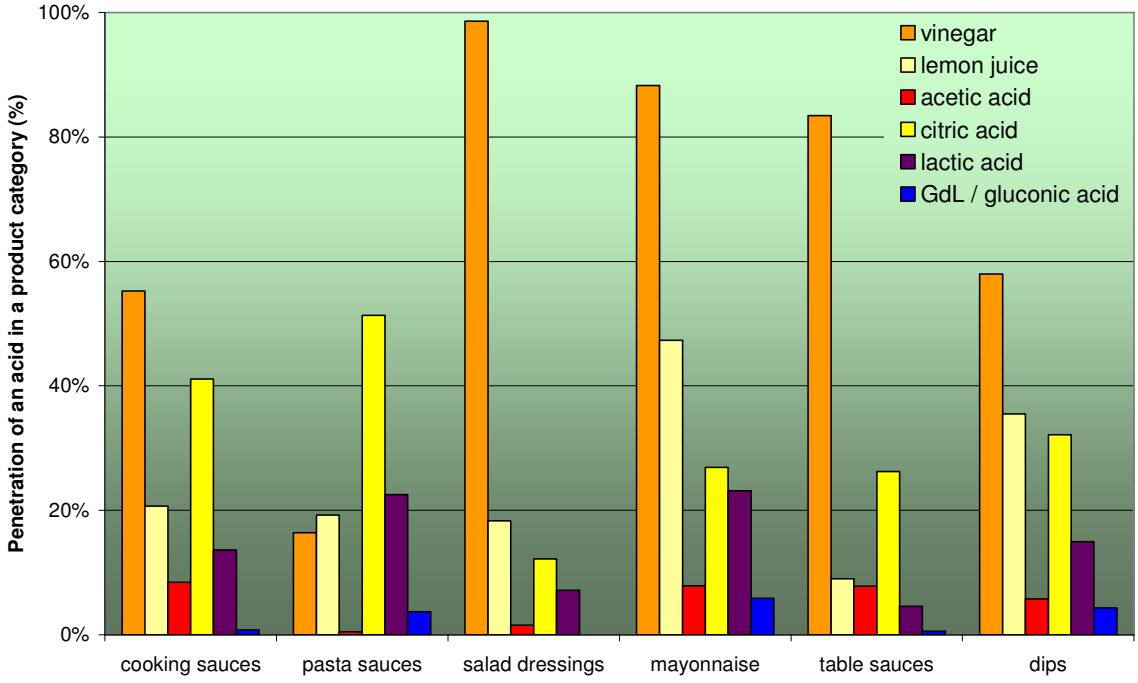


Table sauces and salad dressings are important and innovative categories of sauces and dressings, thus showing numerous product launches, particularly with vinegar. But vinegar is also the primary acid component in those products. Accordingly its penetration in those categories is very high, with 99% of the dressings and 83% of the table sauces launched since January 2008 containing vinegar (Fig. 3). But the penetration of vinegar is also very high in mayonnaise and relatively high dips and cooking sauces.

In pasta sauces however, the situation is different with citric acid being the primary acid component. The relative importance of lemon juice is the highest in mayonnaise and in dips where it is sometimes used as the primary acid ingredient. Lactic acid crosses the 20% penetration mark in both pasta sauces and mayonnaise, but in mayonnaise it ranks only 4th while it ranks 2nd in pasta sauces, thereof certain have lactic acid as the primary acid component.

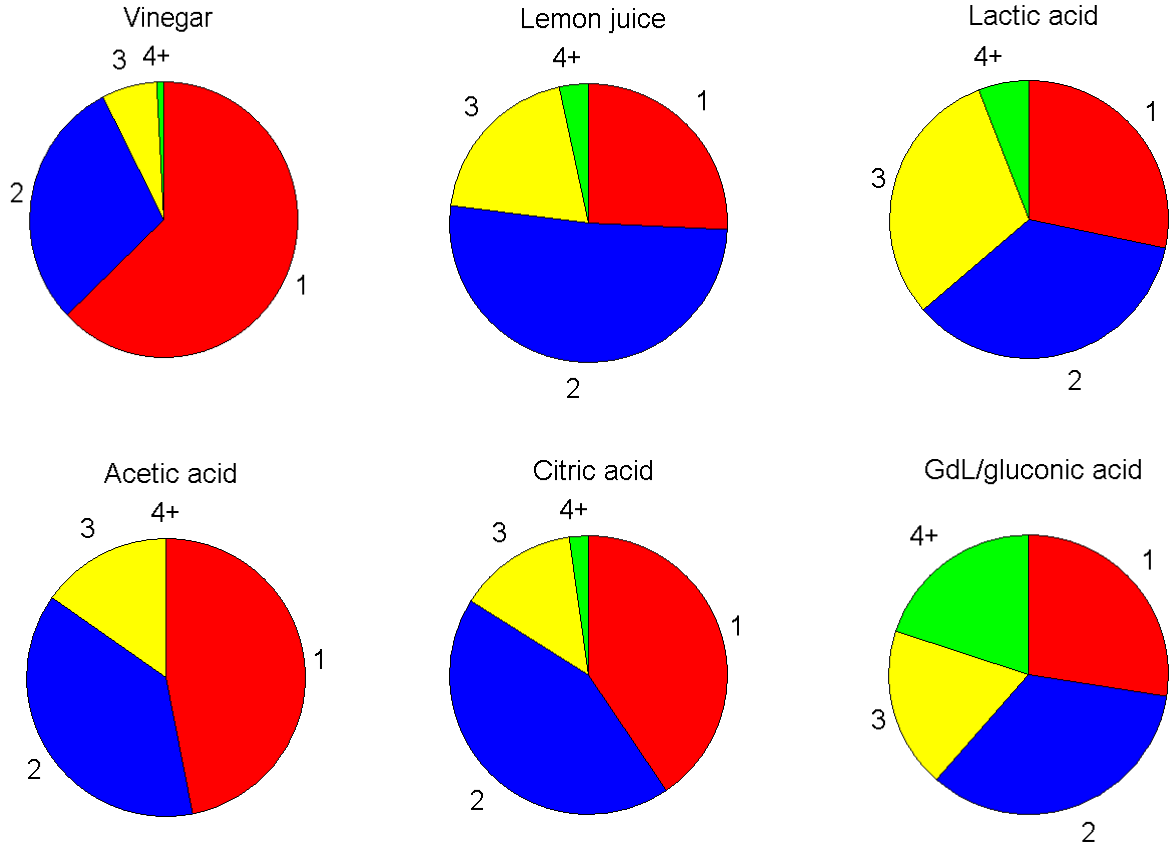
Fig. 3: Acid penetration in sauces and dressings launches since January 2008



In fact, sauces and dressings producers often incorporate more than only one acid, and sometimes up to 4 or 5 to meet all their targets in terms of product taste, safety and economics.

Vinegar and to a lesser extent its pure form acetic acid are the most frequently used alone (Fig. 4), especially in salad dressings and in table sauces. Citric acid is often used alone in tomato and other cooking sauces or in combination with 1 other acid, for example in salad dressings, while lemon juice is frequently combined with 1 other acid, but also regularly with 2. Lactic acid and GdL / gluconic acid are often combined with 2, 3 or more other acids, except in pesto sauces where they are used alone.

Fig. 4: Number of components in acidifying systems of sauces and dressings containing a defined acid (example: within the sauces and dressings containing vinegar, 63% have only 1 acid component, i.e. vinegar, 29% have 2 acid components like vinegar + lemon juice or vinegar + citric acid or vinegar + lactic acid, etc., 7% have 3 acid components like vinegar + lemon juice + citric acid or vinegar + lemon juice + lactic acid, etc, and 1% has 4 acid components like vinegar + lemon juice + citric acid + lactic acid).



SOURNESS

The sourness perception of an acid depends on the nature of the acid, on the concentration of the acid in the medium in which sourness is determined, on the pH of the medium, as well as on the presence and concentration of other ingredients in this medium.

An acid can be characterised by its strength and its intrinsic sourness profile. The strength of an acid determines the amount of acid needed to lower the pH of a medium to a certain value (the stronger the acid, the less is needed to reach the desired pH). It depends on the number of acid functions in the molecule, on their ability to loose a proton (pKa value of the acid function), and to a lesser extent on the molecular weight of the acid (the higher the molecular weight, the lower the number of acid molecules in 1kg of acid, and the higher the amount of acid needed to reach the desired pH).

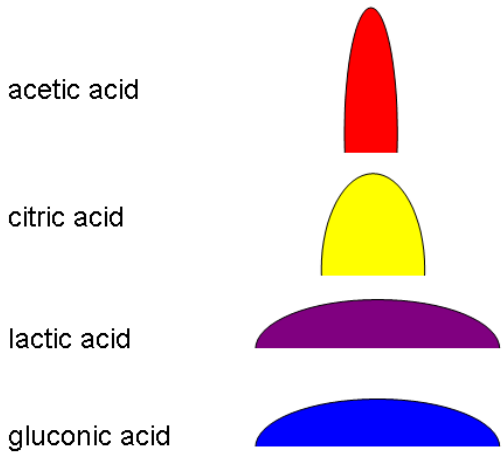
Among the acids typically used in sauces and dressings, citric acid is the strongest because it has 3 acid functions in the molecule and the first to dissociate (= loose a proton) has a low pKa value around 3.1 (Table 1.). Acetic acid is the weakest with its relatively high pKa value of 4.76. Lactic and gluconic acids have very similar pKa values, yet less lactic acid than gluconic acid is needed to reach a defined pH because a lactic acid molecule weighs only half of a gluconic acid molecule.

Table 1: pKa values and molecular weight of typical acids used in sauces and dressings

	pKa1	pKa2	pKa3	molecular weight (g/mol)
citric acid	3.09	4.75	6.40	192
gluconic acid	3.84	-	-	196
lactic acid	3.86	-	-	90
acetic acid	4.76	-	-	60

The sourness profile of an acid is characterised by intensity (sharp or mild) and lasting time (short or long). Acetic acid and to a lesser extent citric acid provide a sharp sourness that fades quickly while lactic acid and gluconic acid have a mild lingering sourness (Fig. 5).

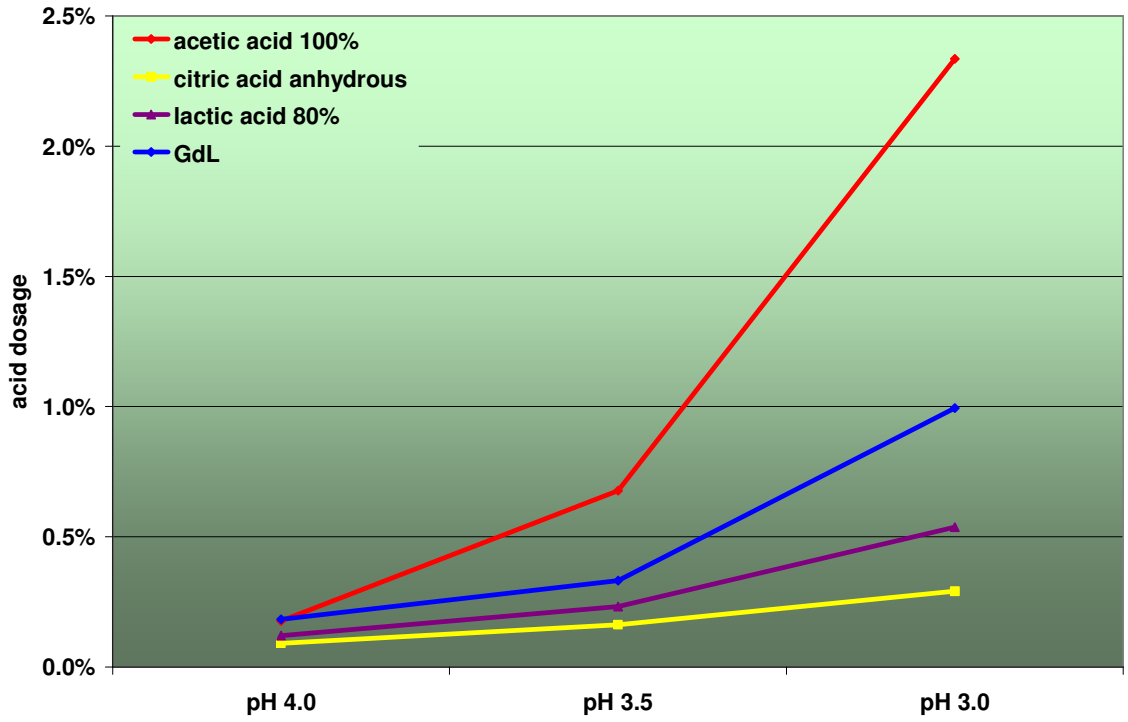
Fig. 5: Sourness profile of typical acids used in sauces and dressings



To evaluate the impact of the acid concentration and the pH on the sourness perception of acetic, citric, lactic and gluconic acids in sauces and dressings, Jungbunzlauer has added the different acids individually to model systems at the needed concentration to achieve a defined pH. For salad dressings for example, 2 model systems have been tested: one with 20% oil content representing a regular salad dressing and one with 5% oil content representing a light salad dressing. For both model systems, the pH has then been reduced to 4.0, 3.5 and 3.0 in different samples using the different acids alone.

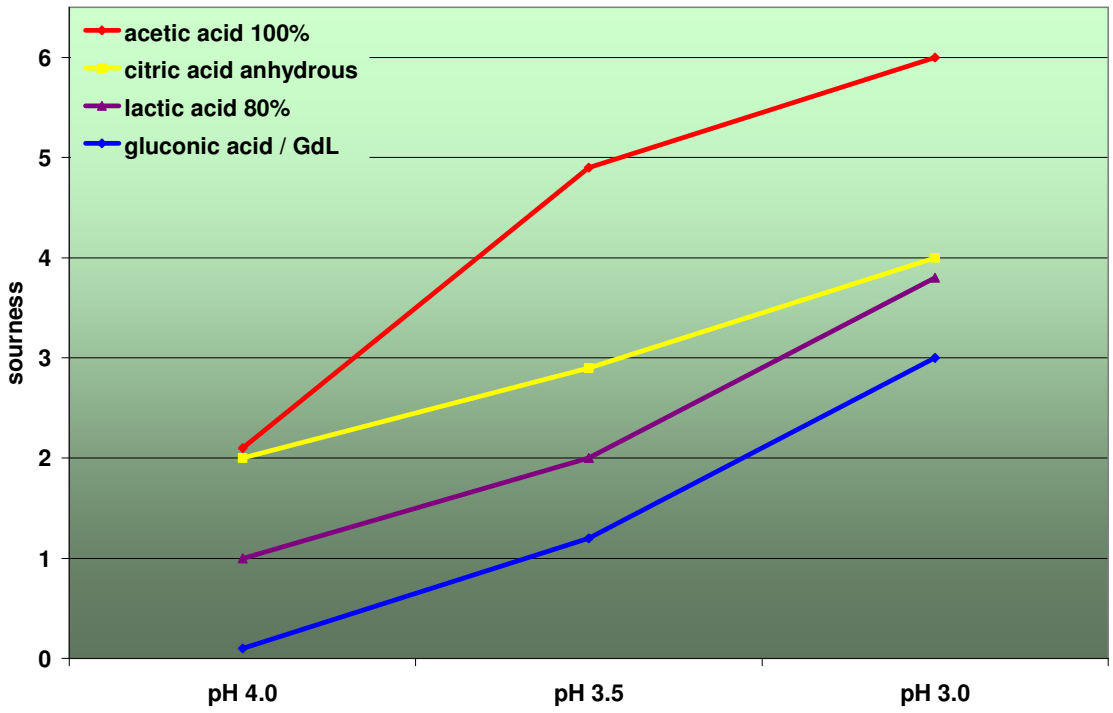
Because acetic acid is the weakest acid of the range and because a pH value of 3.0 is already far below its pKa value, the amount of acetic acid needed to reduce the pH to 4.0, 3.5 and 3.0 increased exponentially (Fig. 6). As Jungbunzlauer nevertheless found on supermarket shelves salad dressings with a pH value down to 3.1, a pH value of 3.0 is not considered out of scope for a model system of a salad dressing. On the contrary, the amount of citric acid needed to reduce the pH of the salad dressing down to 3.0 stayed very limited because of its multiple acid functions and the low pKa value of its first acid function which make it the strongest acid of the range. For lactic and gluconic acid, the trials reflected the impact of the molecular weight on the amount of acid needed to drop the pH value to 3.0 for acids with very similar pKa values.

Fig. 6: Acid dosage in a model system of a regular salad dressing with 20% oil content to decrease the pH to 4.0, 3.5, and 3.0



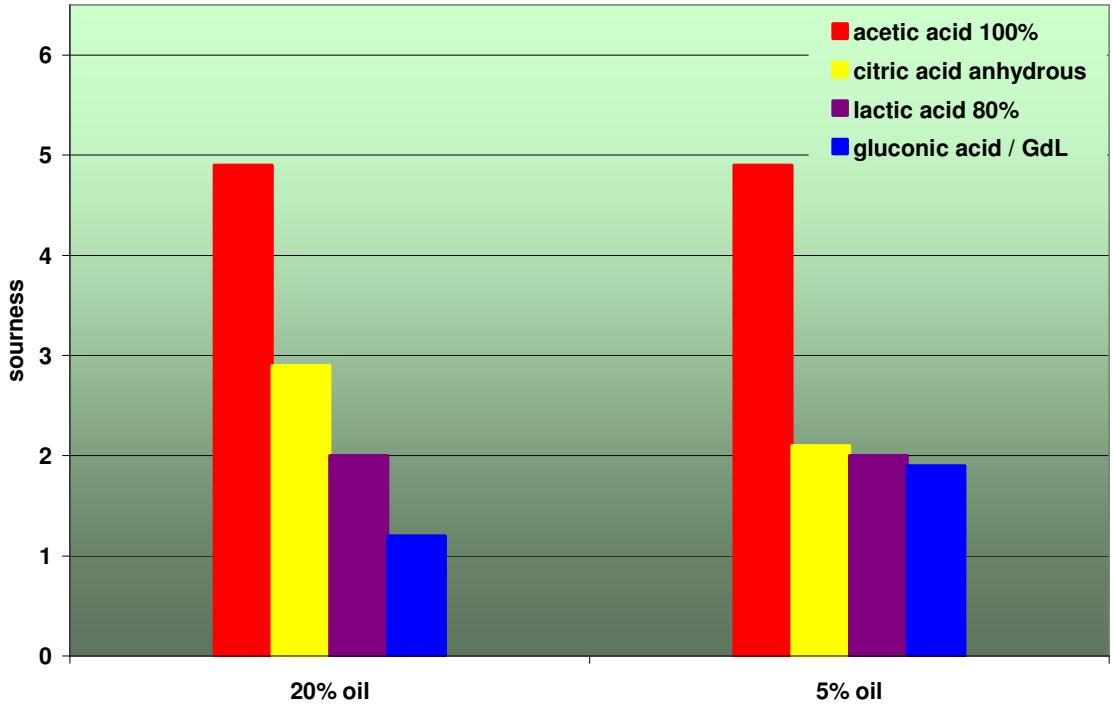
In the model system of a regular salad dressing with 20% oil content, acetic acid showed the highest sourness, especially at pH levels of 3.5 (very strong sourness) and 3.0 (extremely strong), probably also linked to the exponential dosage of acetic acid needed to reach these pH levels (Fig. 7). Citric acid sourness got from weak to strong when pH was decreased from 4.0 to 3.0, but increased less than for the other acids as its dosage increased limitedly only. Interestingly, although dosed higher, gluconic acid showed a lower sourness than lactic acid over the full pH range. At pH 4.0, the sourness of gluconic acid was almost not noticeable (very weak for lactic acid) and increased to clear at pH 3.0 (strong for lactic acid like for citric acid). GdL / gluconic acid thus have a high ability to control the perceived sourness when incorporated adequately in regular salad dressings.

Fig. 7: Sourness perception in a model system of a regular salad dressing with 20% oil content at pH 4.0, 3.5, and 3.0 (blind test, expert sensory panel n = 11, intensity scale: 0 = not noticeable, 1 = very weak, 2 = weak, 3 = clear, 4 = strong, 5 = very strong, 6 = extremely strong).



When comparing the sourness perception of the different acids in the 2 model systems of a salad dressing (regular with 20% oil content and light with 5% oil content) at pH 3.5 which is well representative of the salad dressings available on the market, it becomes obvious that the concentration of other ingredients, in this case oil, also has an impact on sourness perception, but interestingly, reducing the oil content does not change the sourness perception of all acids in the same manner. While the sourness of acetic acid and lactic acid is as intense in a light salad dressing model as in a regular one, citric acid tastes less sour in the light version than in the regular one, while for gluconic acid it is the opposite (Fig. 8). GdL / gluconic acid thus are particularly advisable to control the perceived sourness in high oil content products.

Fig. 8: Sourness perception in a regular salad dressing with 20% oil content and in a light salad dressing with 5% oil content at pH 3.5 (blind test, expert sensory panel n = 11, intensity scale: 0 = not noticeable, 1 = very weak, 2 = weak, 3 = clear, 4 = strong, 5 = very strong, 6 = extremely strong).



WHY GdL / GLUCONIC ACID?

GdL / gluconic acid provide long lasting sourness which is very mild even at concentrations up to 1% as GdL in a regular salad dressing. The sourness perception of gluconic acid is even milder in high oil content products, making it particularly suitable for mayonnaise and pesto sauce. But it can give a round, well-balanced taste to more types of sauces and dressings when combined with other acids.

The very mild taste of gluconic acid is also beneficial for the preservation of sauces and dressings as the development of most bacteria responsible for food spoilage and food poisoning is stopped below pH 4.0 or 3.5. Indeed, the combination of the stronger citric acid with the mild GdL / gluconic acid allows to push pH reduction below these levels without compromising taste. The consequence is triple:

- the lower pH limits better the development of microorganisms
- at this lower pH, a high proportion of the preservative, either synthetic in the form of sorbates or benzoates, or natural in the form of vinegar, is undissociated as all those acids have a pKa above 4 (4.18 for benzoic acid, 4.76 for sorbic and acetic acids). It is known that only the undissociated form of an acid acts antimicrobial. Thus these preservatives are made more effective.
- below 3.5 also a significant proportion of the gluconic acid itself is undissociated and can be used as preservative (patent EP 0 689 773 B1)

On the contrary, when the pH is above 3.5 and better above the pKa of gluconic acid (3.84), a higher proportion of gluconic acid is dissociated. Gluconic acid forms very stable chelates with iron and copper ions which catalyse oxidative rancidity. But it is known that only the dissociated form of an acid acts as a chelating agent. Thus, if GdL / gluconic acid is used for chelation purposes in dressings and sauces, attention shall be paid to keep the pH above 3.8 for optimal effectiveness. In these conditions, initial trials have shown that GdL / gluconic acid can replace synthetic and strictly limited EDTA in mayonnaise.

The different acids used in sauces and dressings all have their strengths and weaknesses (Table 2). As a result, acid combinations often make sense for producers of sauces and dressings to meet their targets in terms of product taste, microbial and oxidative stabilities, naturalness and costs.

Table 2: attributes of acids used in sauces and dressings (+++ = excellent, ++ = good, + = fair, (-) = limited, (--) = poor, (---) = very poor)

	acid strength	mildness	preservation	chelation	naturalness	cost when used alone
vinegar	(-)*	(--)	+++	(-)	+++	(--)
lemon juice	+++*	(-)	+	++	+++	(---)
acetic acid	(-)	(---)	+++	(-)	(---)**	+++
citric acid	+++	(-)	+	++	++	+++
lactic acid	++	++	++	+	++	++
GdL/gluconic acid	+	+++	++	+++	++	+

* acid strength of the corresponding pure form of acid component, dosage in fact much higher because diluted
** rating for synthetic acetic acid from petrochemistry (would be ++ for fermented product)

GdL OR GLUCONIC ACID?

Jungbunzlauer GdL is a dry, highly pure product giving colourless solutions when dissolved in water. Dissolution is fast, but hydrolysis to gluconic acid is progressive, thus pH reduction is progressive as well. If a fast pH reduction is wished, it is recommended to add GdL before or in a warm step of the production process as its hydrolysis is temperature dependent and much faster at 30-40°C than at 10-20°C.

If pH reduction shall be immediate whereas the process is purely cold, Jungbunzlauer recommends the use of its food grade gluconic acid. This product is a yellowish 50% solution of gluconic acid in water, offering the same convenient handling as vinegar, LIQUINAT® (Jungbunzlauer 50% citric acid solution) or lactic acid. Gluconic acid is however safer and much less corrosive than those acids. Gluconic acid shall be stored above 15°C to avoid crystallisation to GdL.

Both products are odourless, kosher, halal and natural. GdL is further permitted in organic products in USA. Jungbunzlauer considers its GdL and gluconic acid as natural because:

- they are made by a natural process, i.e. microbial fermentation
- they are based on natural renewable carbohydrates as raw materials
- gluconic acid occurs naturally in honey and fermented drinks

CONCLUSION

Certain producers of sauces and dressings have already recognized that GdL / gluconic acid can bring them benefits as a mild tasting acid component in sauces and dressings. The particularly mild sourness of gluconic acid in high oil content products makes that GdL is used as the unique acid component or combined with lactic acid in some famous Italian pesto sauce brands. Also the world's leading mayonnaise and dip brands have GdL in certain of their recipes, and several cheese and satay sauces contain GdL as well.

When GdL is combined with other acids, market data show that currently preferred combinations are with vinegar and with lactic acid, but combinations with citric acid and combinations with 2, 3 and even 4 other acids can also be found.

In Jungbunzlauer's view, producers of sauces and dressings can make their products tasting better by incorporating GdL or gluconic acid further in:

- pesto sauce (GdL or gluconic acid can be the unique acid component)
- cream, cheese sauces and dips (in combination with citric acid and/or lactic acid)
- regular and light salad dressings, mayonnaise and ketchup (in combination with vinegar)

Producers of sauces and dressings can further implement their strategies to eliminate synthetic preservatives by optimizing the proportion of vinegar, citric acid, lactic acid and GdL / gluconic acid in their combinations to go lower in pH without compromising taste.