

Glucono-delta-Lactone (GdL)

A Natural Way of Leavening



Presented by:

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INTRODUCTION

Glucono-delta-lactone (GdL) is a neutral cyclic ester of gluconic acid formed by the removal of water. Gluconic acid is an organic acid occurring naturally in plants, fruits and other foodstuffs such as wine (up to 0.5%) and honey (up to 1%).

Jungbunzlauer manufactures gluconic acid from renewable carbohydrate sources by a natural microbial fermentation. The crystallisation of gluconic acid produces GdL as a fine, white, crystalline powder freely soluble in water. GdL is practically odourless and has a slightly sweet taste. Being non toxic, it is completely metabolised in the body like a carbohydrate.

When added into an aqueous solution GdL dissolves rapidly into the medium. Subsequently it hydrolyses slowly to gluconic acid, thus decreasing the pH in a progressive and continuous manner to equilibrium (Fig. 1). This gentle acidification makes GdL outstanding compared to the instantaneous acidification obtained with other acidulants. Further, the initial sweet taste of GdL becomes only slightly acidic during its hydrolysis. Therefore, the final flavour of an aqueous solution of GdL remains much less tart than the one of other common food acids (relative sourness of gluconic acid is only 1/3 of citric and lactic acids and 1/4 of acetic, malic and tartaric acids).

These two properties set GdL apart from other acidulants and allow its use in applications requiring a continuous and controlled reduction of pH and/or a neutral flavour profile.

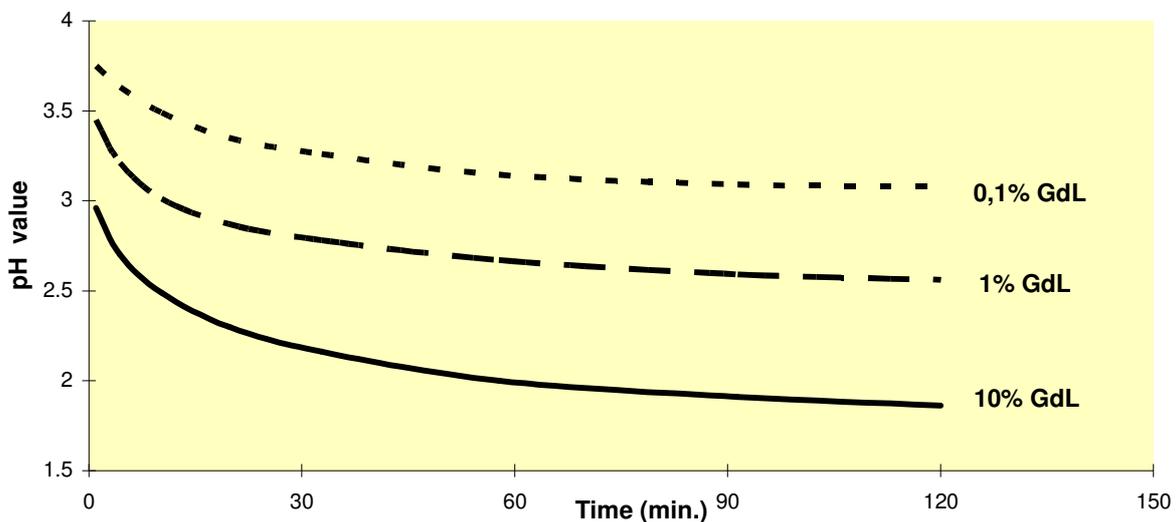


Fig. 1: Hydrolysis of GdL in water at 25°C: pH as a function of time.

LEGAL ASPECTS

In the European Union, GdL is a generally permitted food additive (E575). It may be added to all foodstuffs, following the "quantum satis" principle, as long as no special regulation restricts the use (2006/52/EC).

The US Food and Drug Administration (FDA) assigned GdL the "generally recognised as safe" (GRAS) status and permitted its use in food without limitation other than current good manufacturing practice (GMP) (21 CFR Ch. I §184.1318).

In the USA, GdL also belongs to the nonagricultural (nonorganic) substances allowed as ingredients in or on processed products labelled as „organic“ or „made with organic (specified ingredients of food group(s))“ according to the US Department of Agriculture (USDA) 7 Code of Federal Regulation (CFR) § 205.605.

In the International Numbering System of the Codex Alimentarius, GdL has the INS number 575 and is categorised as an acidifier/acidity regulator as well as a leavening agent.

The Acceptable Daily Intake (ADI) of GdL has been established "not specified" by the Joint Expert Committee on Food Additives (JECFA) of the FAO/WHO and the Scientific Committee for Food (SCF) of the European Community.

Purity criteria have been laid down for GdL by the Food Chemicals Codex (FCC), JECFA, the Directive 2008/84/EC of the Commission of the European Communities, etc.

FEATURES AND BENEFITS OF GdL IN BAKERY PRODUCTS

History

The production of gas in baked goods, also called leavening or raising, plays a major role in the product's texture and appearance. In ancient times, leavening was first achieved keeping a portion of one's day dough as a starter for the next day's bread, and later by the incorporation of baker's yeast into the dough. The use of chemicals as leavening agents has then developed from the 1850's. Today, biological leavening, i.e. yeast fermentation, is still the most important in bread production, but chemical leavening systems are presently used in a wide range of bakery products, either alone or in combination with yeast.

Non-yeast leavening systems produce the carbon dioxide that is necessary for the raising of the kneaded dough through the reaction of a carbon dioxide source, mainly sodium bicarbonate, with one or more leavening acids. One of these is GdL that was first used as a leavening acid in the 1940's.

Reaction of GdL with sodium bicarbonate

GdL and sodium bicarbonate (E500ii) do not react in the dry state, making their blend shelf stable. However, when water is added to their mix with the other dry ingredients of a dough or batter, GdL and sodium bicarbonate quickly dissolve. Subsequently, GdL hydrolyses slowly to gluconic acid which then reacts with the sodium bicarbonate to release carbon dioxide (Fig. 2). Particularly interesting is the slowness of GdL's hydrolysis at room temperature and below, and its acceleration with an increase in temperature: hydrolysis time is reduced to half for ca. every 10°C rise in temperature. Therefore, very little acid is formed during dough preparation and refrigerated storage with the resulting small loss of carbon dioxide at these stages.

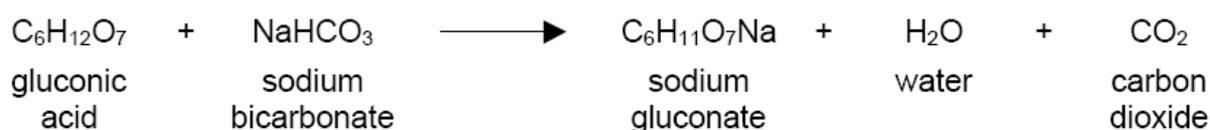


Fig. 2: Leavening by reaction of gluconic acid with sodium bicarbonate.

Features of leavening acids

The two most important features of a leavening acid are the neutralising value (NV) and the dough rate of reaction (DRR).

The NV refers to the parts by weight of sodium bicarbonate that can be neutralised by 100 parts by weight of leavening acid (Fig. 3). It is a function of the number of free acid groups and of the molecular weight of the leavening acid. When using other sources of bicarbonate, the NV changes: for ammonium bicarbonate it changes by a factor of 0.94, for potassium bicarbonate by a factor of 1.19.

The DRR refers to the rate at which carbon dioxide is released compared to the total available carbon dioxide. It is associated with the rate at which the proton of the acid becomes available to react with the bicarbonate, thus reflecting the speed of reaction of a leavening acid (Fig. 3 and Fig. 4).

Leavening acid		NV	DRR
Cream of tartar	potassium acid tartrate (E336)	45	fast
GdL	glucono-delta-lactone (E575)	47	slow to intermediate
SAPP	sodium acid pyrophosphate (E450i)	72	slow to very slow
MCPM	monocalcium phosphate monohydrate (E341i)	80	fast
AMCP	anhydrous monocalcium phosphate (E341i)	83	intermediate
SALP	sodium aluminium phosphate (E541)	100	very slow

Fig. 3: NV and DRR of the most common leavening acids.

The DRR is a function of the type of leavening acid, sometimes of its physical characteristics such as particle size, and of temperature. Further, it will also be affected by other formulation factors like sugar concentration, presence of divalent cations such as calcium and presence of water-binding components such as starches and gums.

The various acids differing in their DRR in response to elevation of temperature, mixtures of acids may be suitable to achieve a particular reaction time.

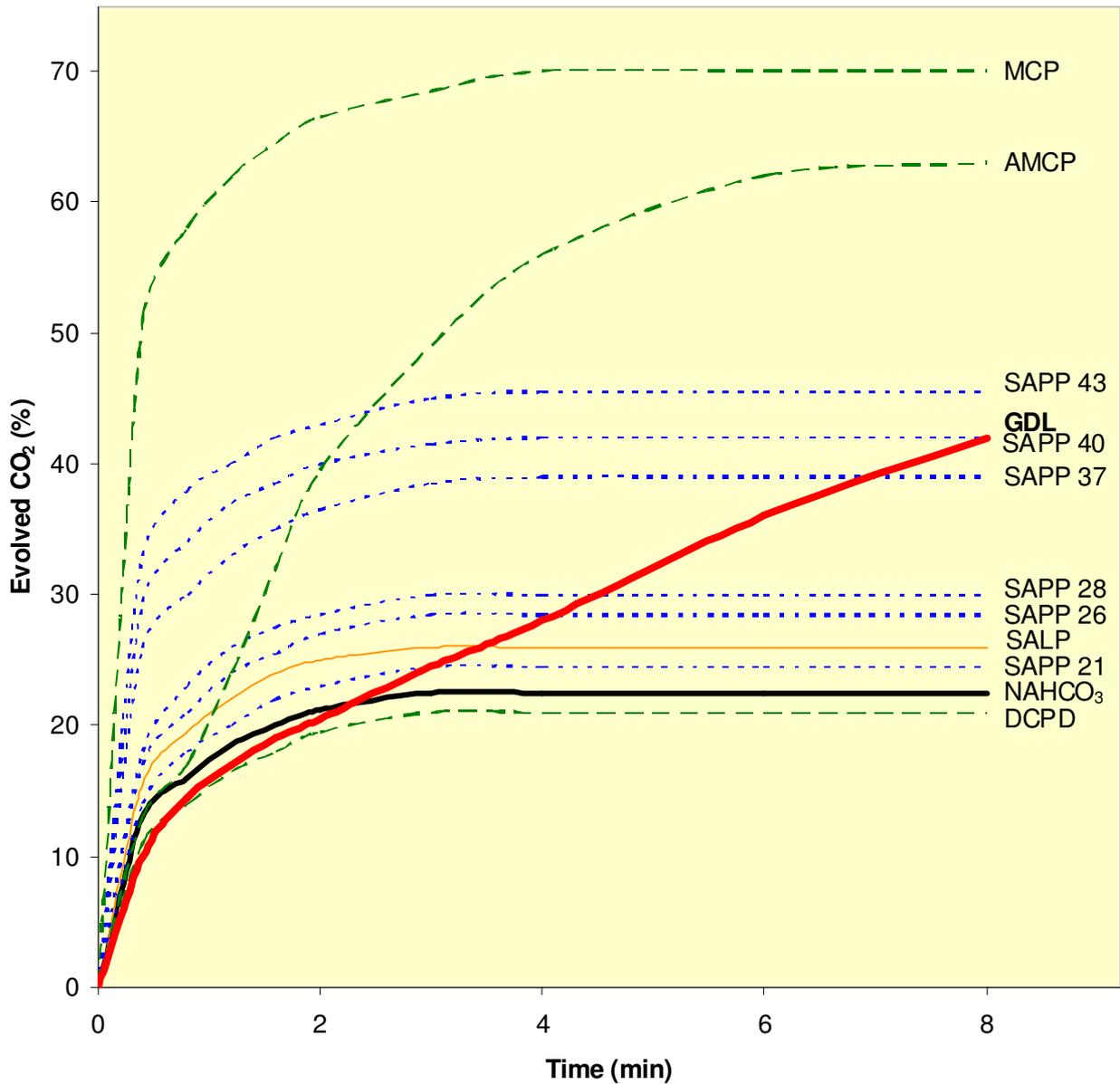


Fig. 4: Dough rate of reaction (DRR) of various leavening acids (3 minutes mix time at 27°C, simple biscuit mix). The soda blank curve includes all of the ingredients except the leavening acid.

In general, the desired carbon dioxide release in dough is 0.5% by flour weight, or more. Thus, at least 1% sodium bicarbonate must be added to the dough. The amount of GdL to completely neutralise 1% sodium bicarbonate can then easily be calculated using the NV of GdL ($1\% \times 100 / 47 = 2.12\%$). The leavening acid and soda are generally used in a proportion leaving only little, if any, unreacted soda or acid in the product after baking. These proportions can be different when particular effects related to the pH of the finished product are desired, i.e. colour, taste or preservation.

Actually, when the leavening acid is GdL, it can be overdosed to achieve an acidic pH that retards microbial development. Phosphates can not do this as they buffer the pH in the neutral range: MCPs buffer at 6.9, SALP at 7.1-7.2 and SAPPs at 7.3-7.6. GdL thus offers additional features as an acidifier and preservative agent enhancer.

In muffins, we determined that a GdL overdosage of up to 40% is possible without any drawbacks on taste. At this highest organoleptically acceptable overdosage, the test muffins had a pH of 6.3 (Fig. 5). They did not show any sign of mould development even after 19 days of storage at room temperature.

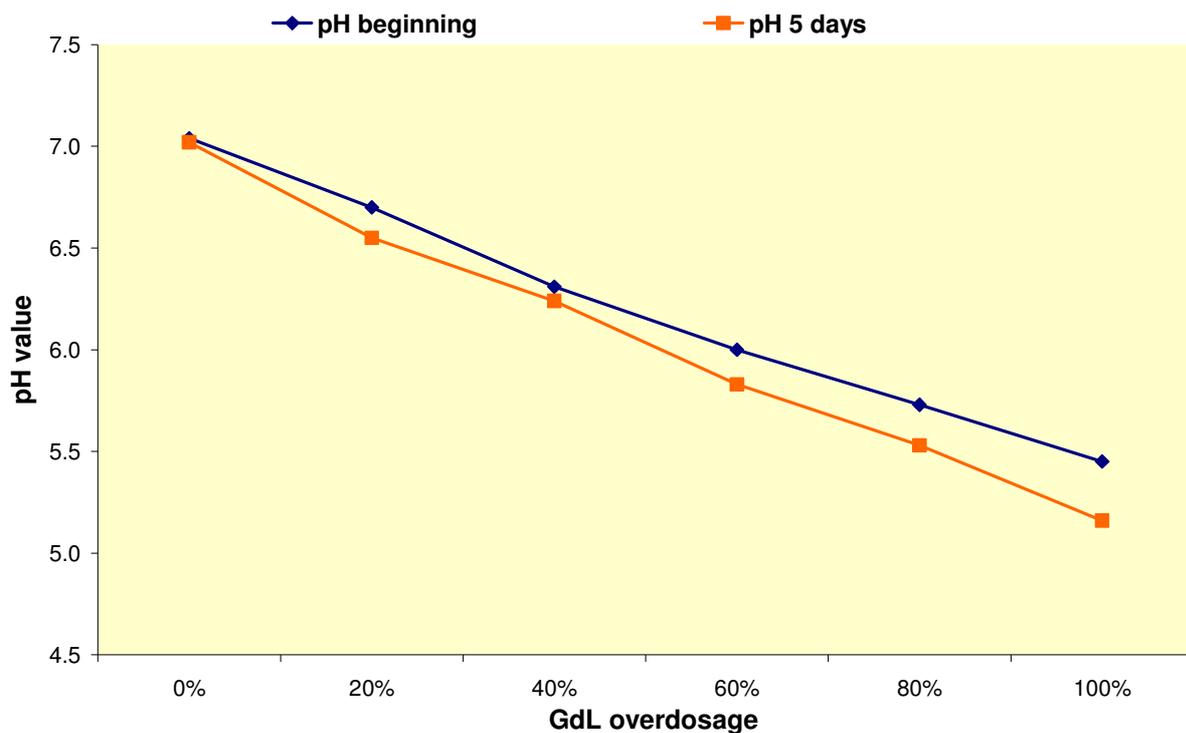


Fig. 5: pH of muffins as a function of the GdL overdosage.

Benefits of GdL

GdL offers numerous benefits compared to the common leavening phosphates and cream of tartar.

Naturalness:

We consider Jungbunzlauer GdL as natural for the following reasons:

- it is made from natural renewable carbohydrates as raw materials
- it is made by a natural process, microbial fermentation
- gluconic acid, the dissolved form of GdL, occurs naturally in fruits, honey, etc.

Versatility:

As GdL's DRR is slow to intermediate and as temperature control further allows to slow down or speed up the conversion of GdL to gluconic acid and thus the rate of carbon dioxide release, GdL can replace both fast (MCPs) and slow (SAPPs) phosphates.

Taste:

With its typical mild taste, GdL allows baked goods to express their true natural flavour, while the typical off-notes such as bitterness and soapiness caused by the use of pyrophosphates do not occur (Fig. 6).

Appearance and texture of crumb and crust:

GdL creates a lighter crumb colour, a more homogeneous cell structure (less tunnels) and suppresses the risk of black specks on the crust. Increased volumes of baked goods can also be achieved thanks to well controlled gas release (Fig. 6).

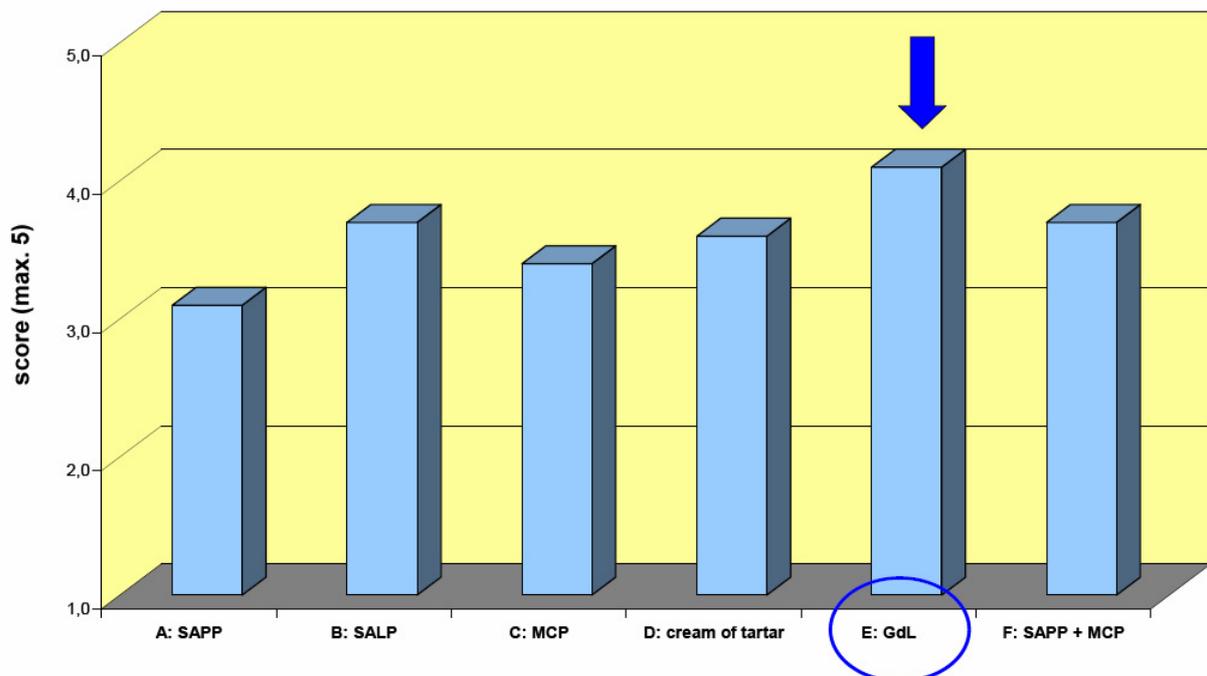


Fig. 6: Sensory evaluation of muffins in a blind test , panel n = 7, total score based on a) form/shape, b) crust properties, c) crumb properties, d) texture/mouthfeel, e) odour/taste.

Shelf life:

A 40% overdosage of GdL acidifies the baked good, slows down mould development significantly and thus prolongs shelf life in a natural way without negative effects on taste. This is not possible with phosphates as they buffer the pH of the baked good at approx. 7.

Sodium reduction:

In bakery products, more than 95% of the sodium content comes from three sources: salt, sodium bicarbonate and the leavening acid (Fig. 7). Salt is not easy to replace due to its taste and technological benefits. Sodium bicarbonate may be replaced by potassium bicarbonate but due to its cost and taste this is not a real alternative. Thus, the substitution of the sodium containing leavening acids is the easiest way to reduce sodium.

When replacing SAPP with GdL, a sodium reduction of 25-35% can be achieved while improving product quality. GdL thus enables bakers to label their products with the nutrition claims “reduced sodium” or “light in sodium” under the EU Nutrition and Health Claims Regulation.

	Yellow cake	Muffins	Biscuits
Salt	42%	29%	52%
Sodium bicarbonate	26%	33%	23%
SAPP	27%	34%	24%
% of total sodium	95%	96%	99%

Fig. 7: Main sodium sources in selected types of bakery products.

Aluminium reduction:

Following a new toxicological evaluation of aluminium in 2006, JECFA (Joint FAO/WHO Expert Committee on Food Additives) revised Aluminium’s PTWI (Provisional Tolerable Weekly Intake) down from previous 7mg/kg bw to 1 mg/kg bw. EFSA (European Food Safety Authority) recently aligned with JECFA.

Bakers working with SALP claim that they use it because it gives baked goods a better taste than SAPP, a more appealing product appearance (lightness and texture) and a better mouthfeel. GdL producing at least such high quality bakery products as SALP, it is a real alternative for bakers concerned by the aluminium content of their products.

USE OF GdL IN BAKERY PRODUCTS

Thanks to its versatility and mild taste, GdL has been used for decades in high quality baking mixes for home use, especially in mixes for muffins, cakes, bread, pizza, etc. At the same time, the possibility of fine-tuning the rate of carbon dioxide release by controlling the temperature allowed the incorporation of GdL in high-tech canned refrigerated dough products. As freezing does not affect its raising capacity, GdL has also been used for years already in deep frozen self rising crust pizzas. More recently, finished cakes, biscuits and cookies as well as cereal bars with GdL have appeared on the market.

Jungbunzlauer GdL F2500 has proven to be the ideal grade for bakery applications and is thus the type we recommend bakers to use without any restrictions. Muffin, yellow pound cake, pancake and waffle recipes with Jungbunzlauer GdL F2500 are available on request.

In addition, Jungbunzlauer offers fat coated GdL if the DRR needs to be very slow.

CONCLUSION

Today, the changed economics of phosphates, but also the booming demand for organic and all natural baked goods, in relation with the use restrictions of phosphates in organic products and questions about the naturalness of phosphates put GdL under the spotlights. Also the need of individuals to reduce sodium and aluminium intake while keeping product quality speaks in favour of GdL.

Its unique combination of benefits now makes GdL more interesting than ever as a natural leavening acid, especially for muffins, cakes and pancakes in their organic, natural, sodium-reduced and aluminium-reduced forms.