Jungbunzlauer

From nature to ingredients®

facts

A new approach to supplementation: Calcium citrate gummies

Introduction

While no dietary supplement can replace a balanced diet, their benefits are widely recognised and their usage is currently on the rise. For example, today 77% of adults in the USA take supplements.[1] The reasons for this are manifold: they include a desire to enhance overall wellness or to compensate for nutrient deficits resulting from increased nutrient demand or reduced uptake. Some users are looking for a specific health effect, like improved bone or cardiovascular health. Others may find they need an energy boost in the morning and calming support in the evening to have a restful sleep.

The delivery formats available are as many and varied as the reasons for taking supplements. While tablets, capsules and syrups represent more traditional dosage forms, beverage powders, stick-packed products for direct consumption and gummies are gaining momentum. In line with today's 'on-the-go' lifestyles, consumers are looking for products that are easy to consume, tasty and easy to incorporate into their daily routine. Other desired attributes when choosing supplements include effectiveness and bioavailability, with product safety also gaining in importance. This trend is linked to increased customer awareness of what they are consuming. In consequence, delivery format innovations have become one of the growth drivers in particular in relatively mature supplement markets like Western Europe and the USA.

One of the rising stars among these novel dosage forms are nutritional gummies, also known as gummy supplements. These products utilise the tasty gummy format as a delivery system for nutritional ingredients and go far beyond just fortified gummy bears. The first of these products appeared in the market in the late 1990s, when they were regarded primarily as an alternative delivery format for vitamins, especially those designed for children. These tasty supplements, with their positive connotations, then entered the adult segment, with ingredients that address the specific needs of this consumer group. Having acquired a broader consumer base, gummy supplements proceeded to occupy more space on the supplement shelves. According to data from the Innova database the number of product launches nearly doubled (+87%) between 2015 and 2019.[2]

Gummy products are particularly interesting for macro-mineral products like calcium. In the USA the daily value (DV) for calcium was recently increased from 1000 mg to 1300 mg per day, meaning that traditional supplements in tablet or capsule form have either to be very large or the supplement has to be taken in several doses. This problem may be addressed by using calcium salts with a relatively high mineral content, like calcium carbonate or calcium phosphate. However, this solution involves a compromise in regards to bioavailability, as these inorganic calcium salts are not as effectively absorbed as organic salts like calcium citrate. The latter is the most commonly used calcium salt in premium supplements and demonstrates excellent bioavailability.

While size may pose a challenge for some tablets and capsule products, the formulation of novel dosage forms like gummies leads to other challenges relating to taste and product stability. Therefore, selection of the right ingredients and proper processing is crucial to overcome the challenges.

Challenges in the production of mineral gummies

Gummy products consist of a gelling agent, sucrose, glucose syrup, flavour and colour. Every manufacturer has their established production process and is familiar with handling the ingredients.

When introducing large amounts of new ingredients such as mineral salts, it is necessary to adjust the production process as well as the whole recipe to guarantee a shelf-stable, pleasant-tasting product.

Calcium salts vary in their calcium content, taste and solubility. As soluble calcium salts express a bitter off-taste in higher concentrations, the use of low or insoluble salts is recommended to ensure a pleasant taste. Since these calcium salts are dispersed rather than dissolved in the gummy mass, opacification of the end product occurs. This brings with it the risk of unpleasant mouthfeel, with gummies causing a sandy or gritty sensation on tongue. Therefore the choice of the right calcium salt and its particle size has a tremendous impact on the overall gummy formulation.

Additionally, it is crucial that the salts do not react in the acidic gummy matrix. Calcium carbonate, for instance, leads to foaming during the production of the gummy mass.

Table 1: Common calcium salts and their content

Calcium source	Calcium content	Solubility	Equivalent to 50% DV (650 mg)
Calcium Phosphate	38.8	Practically insoluble	1,675 mg
Calcium Carbonate	40.0	Practically insoluble	1,625 mg
Tricalcium Citrate	21.1	1 g/l	3,080 mg
Calcium Lactate	13.0	66 g/l	5,000 mg
Calcium Lactate Gluconate	13.0	400 g/l	5,000 mg

Adding large amounts of minerals to gummy masses increases the dry matter, leading to faster hardening, shorter shelf life and a decline in quality. As a result, most calcium gummies contain calcium phosphate which has a relatively high calcium content. Products using highly bioavailable calcium citrate are rarely found on the market, as its lower calcium content presents a significant challenge to formulators.

The incorporation of humectants can delay the hardening of gummy products by binding water, which prevents drying out. Lactate, glycerine and sorbitol are commonly used humectants in the confectionary industry.

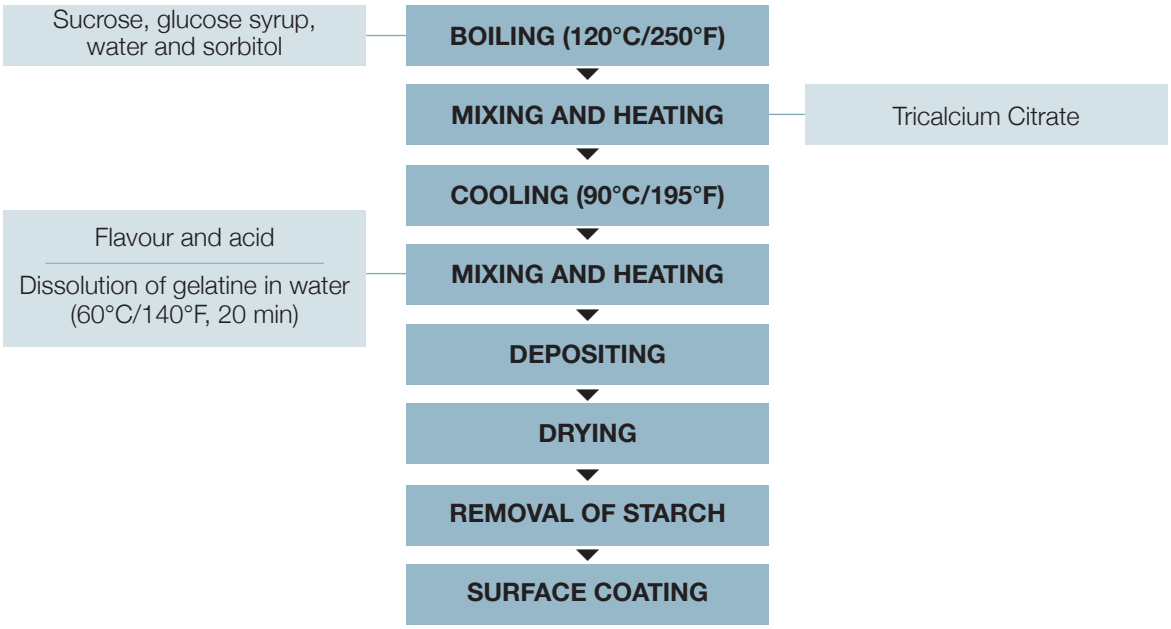
Development of a calcium citrate fortified gummy

Jungbunzlauer has developed a calcium fortified gummy with its tricalcium citrate. Two of these gummies deliver 50% of the calcium daily value, respectively 81% nutrient reference value (DV [US] = 1300 mg, NRV [EU] = 800 mg), the same calcium level that can be found in most market products utilising calcium phosphates as their calcium source. To reach the desired fortification level, 650 mg of pure calcium equal to 3.08 g of tricalcium citrate need to be incorporated into the recipe. This results in tricalcium citrate making up 23% of the recipe.

Production process

These large amounts of mineral salts require modifications to the manufacturing process, as described in figure 1. After boiling sucrose, glucose syrup, water and sorbitol together, tricalcium citrate is added. Thorough mixing is necessary to achieve a homogenous mass and uniform gummies without visible agglomerates. Cooling of the mass to 90°C is mandatory before adding the gelatine, since gelatine is a protein and therefore highly sensitive to hot temperatures. Flavour and colour are added at the end of the process, before depositing the gummy mass in starch beds. Due to the high proportion of dry matter in mineral gummies, the drying time is much shorter compared to regular gummies (24 h vs. several days). Drying is followed by removal of the starch and finally surface treatment such as waxing, sugar coating or acid sanding, depending on the desired end product.

Figure 1: Production of gelatine gummies with tricalcium citrate



Recipe development

In consideration of all the challenges associated with developing a calcium gummy, several parameters were studied with the objective of developing the optimal fortified gummy recipe. Gelatine content and bloom strength, humectants and tricalcium citrate granulation were evaluated in the following gummy recipe (table 2).

Table 2: Recipe for gelatine gummy with tricalcium citrate

Ingredient	Supplier	%
Gelatine 260 bloom	GELITA	4.00
Water		10.70
Sucrose		15.20
Glucose Syrup 42DE	Stockmeier Foods	39.60
Water		3.00
Sorbitol Syrup (70%)	BÄKO	2.50
Tricalcium Citrate M1098	**Jungbunzlauer**	22.80
LIQUINAT® (50% Citric Acid)	**Jungbunzlauer**	1.40
Flavour	Takasago	0.50
Colour	GNT	0.30
Total		**100**

Experimental set-up

In the development phase, each recipe was tested for changes in texture and shelf life. Gummies were evaluated after production and throughout the storage time of several weeks. Measurements covered water activity, texture analysis and sensory evaluation. Water activity was determined using a HygroLab C1 device from Rotronic Ltd.

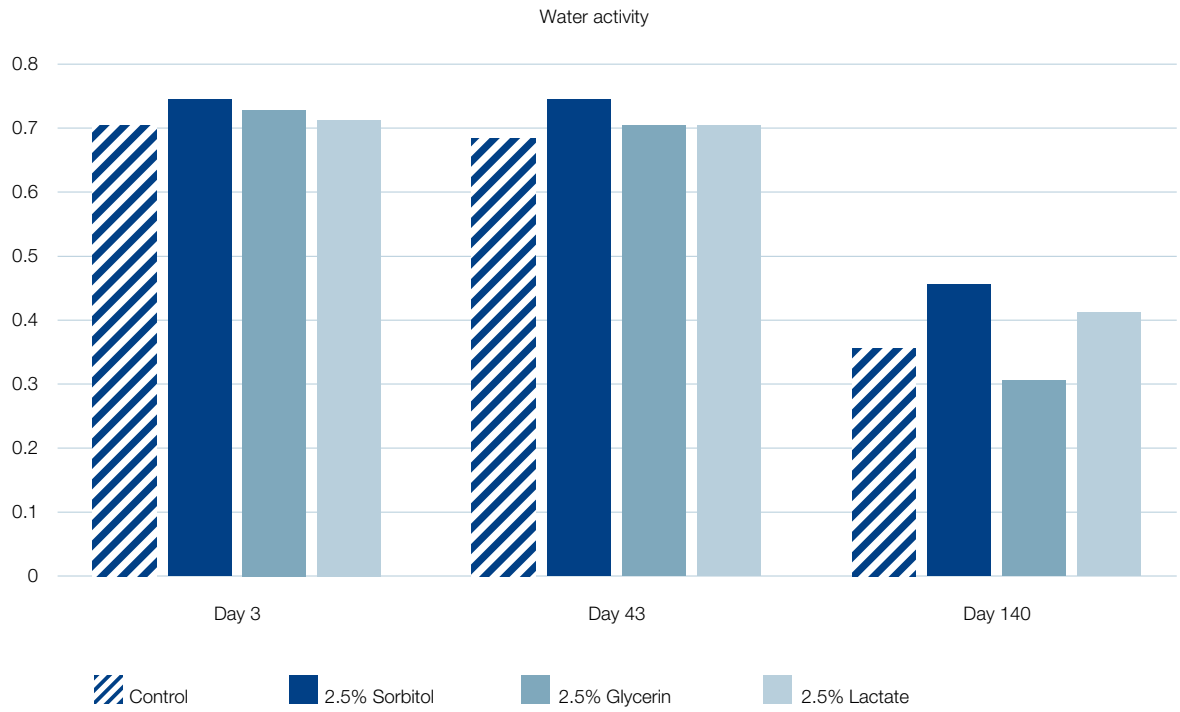
Texture analysis was performed using a Brookfield CT3 with a 38 mm diameter stamp, 1 mm/s testing speed and 0.0988 N trigger point. Gummy samples were deformed to 30% and hardness was evaluated.

With Jungbunzlauer's internal taste panel sensory analysis of gummies in regards to mouthfeel and sandiness was conducted.

Water activity

Sorbitol, sodium lactate and glycerine were compared for their ability to bind water and therefore keep the gummies softer. Water activity was analysed after production and drying until day 140 in open storage at room temperature. Figure 2 shows that sorbitol is most effective in maintaining a higher residual moisture, shown by the slower decrease in water activity. Sodium lactate shows a similar performance to sorbitol, but was inferior in taste and affected viscosity of the gummy mass negatively during production. Its addition led to an increase in viscosity and complicated depositing of the gummies.

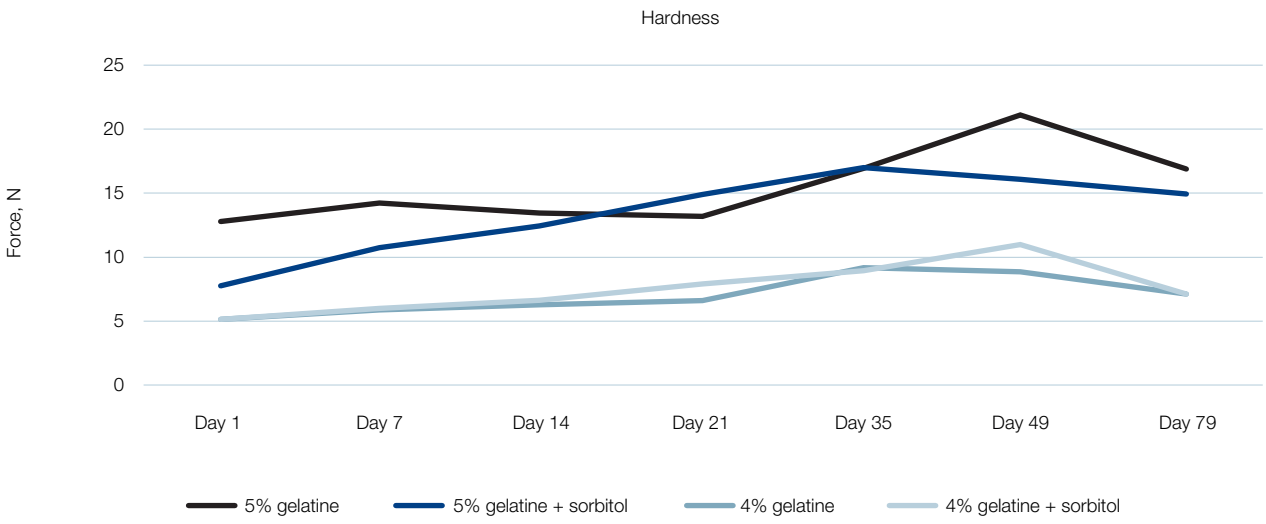
Figure 2: Water activity of gummies with different humectant and 260 bloom gelatine over 140 days of open storage at room temperature



Texture analysis

Gummies were stored in a sealed container and opened daily, to simulate storage conditions at the end consumer. Gummies with 5% gelatine hardened faster than samples containing only 4% gelatine. The addition of 2.5% sorbitol helped to delay the hardening slightly which correlates to the water activity. No positive impact on the texture was observed with 160 bloom gelatine (data not shown).

Figure 3: Hardness of gummies with different concentrations of 260 bloom gelatine with and without 2.5% sorbitol over 79 days strage



Sensory evaluation

Two paired comparison tests were performed to complement results of texture analysis and water activity with sensorial data. Both tests were carried out by a trained sensory panel (n=22).

For every test, two gummies were compared and panellists were asked to identify the sample which was sandier. Two different granulations of tricalcium citrate (M1098 < 10 µm min. 98%/M2090 < 20 µm min. 90%) were compared as well as tricalcium citrate M1098 and calcium phosphate. No off-tastes of either TCC M2090 or M1098 were detected.

Sensory evaluation showed a significant difference in sandiness, with M1098 being less sandy than M2090 (highly significant, p-value < 0.0001). Calcium phosphate was also significantly sandier than tricalcium citrate M1098 (highly significant, p-value < 0.0001).

The results correlate with studies stating the tongue can hardly identify particles below 20 µm. Therefore, all particles coarser than 20 µm impart a sandy and gritty feeling, whereas smaller particles feel smooth.[3] Hence, calcium gummies with Jungbunzlauer's tricalcium citrate M1098 feel smooth on the tongue without detectable mineral particles.

Gelatine and beyond

Gelatine is the undisputed leader amongst gelling agents on the market for gummy products with an elastic bite. However, with the growing trend towards plant-based products and rising awareness of animal well-being, consumers demand vegan options and alternatives to gelatine.

Pectin gummies can be fortified with tricalcium citrate to the same extent as gelatine gummies (23% tricalcium citrate in total gummy mass) as long as a suitable pectin type is used. Another alternative would be starch, which requires larger amounts of water for gelatinisation; this reduces the proportion of tricalcium citrate. Hence up to 12.5% tricalcium citrate can be incorporated into a starch gummy without any drawback in depositing and final texture (data available on request).

Summary

These results prove production of mineral fortified gummies with 50% DV of calcium per two pieces is possible using tricalcium citrate M1098. Four percent gelatine (260 bloom) appears to be the optimal concentration for an elastic bite and pleasant texture. Sorbitol prolongs the shelf life and prevents gummies from hardening too fast, while not having a negative effect on processability. Jungbunzlauer's micronised tricalcium citrate M1098 is the first choice for product developers to combine good processability, pleasant taste and mouthfeel as well as high bioavailability in calcium gummies.

Acknowledgements

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References

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[3] Beckett, S.T.: The science of chocolate (2nd ed.). Cambridge: RSC Publishing, 2008

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. Due to continuous investments, state-of-the-art manufacturing processes and comprehensive quality management, we are able to assure outstanding product quality. Our mission "From nature to ingredients®" commits us to the protection of people and their environment.

Jungbunzlauer offers different granulations of tricalcium citrate for food applications as well as pharmaceutical and personal care products.

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