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BETTER FOR DOUGH

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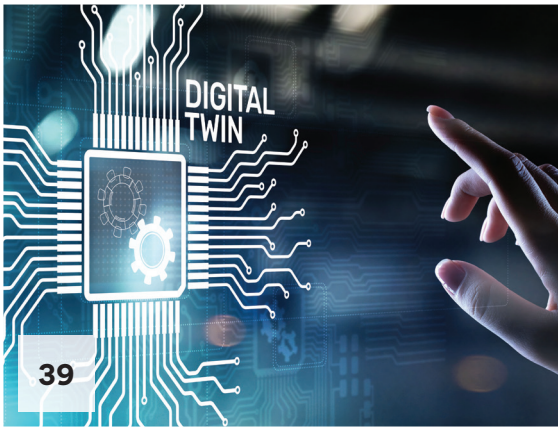

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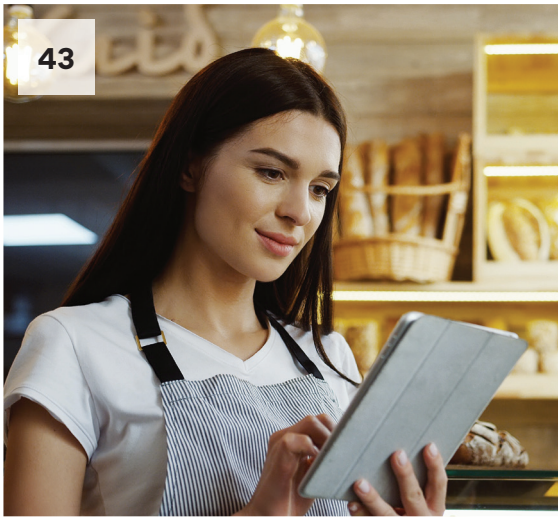
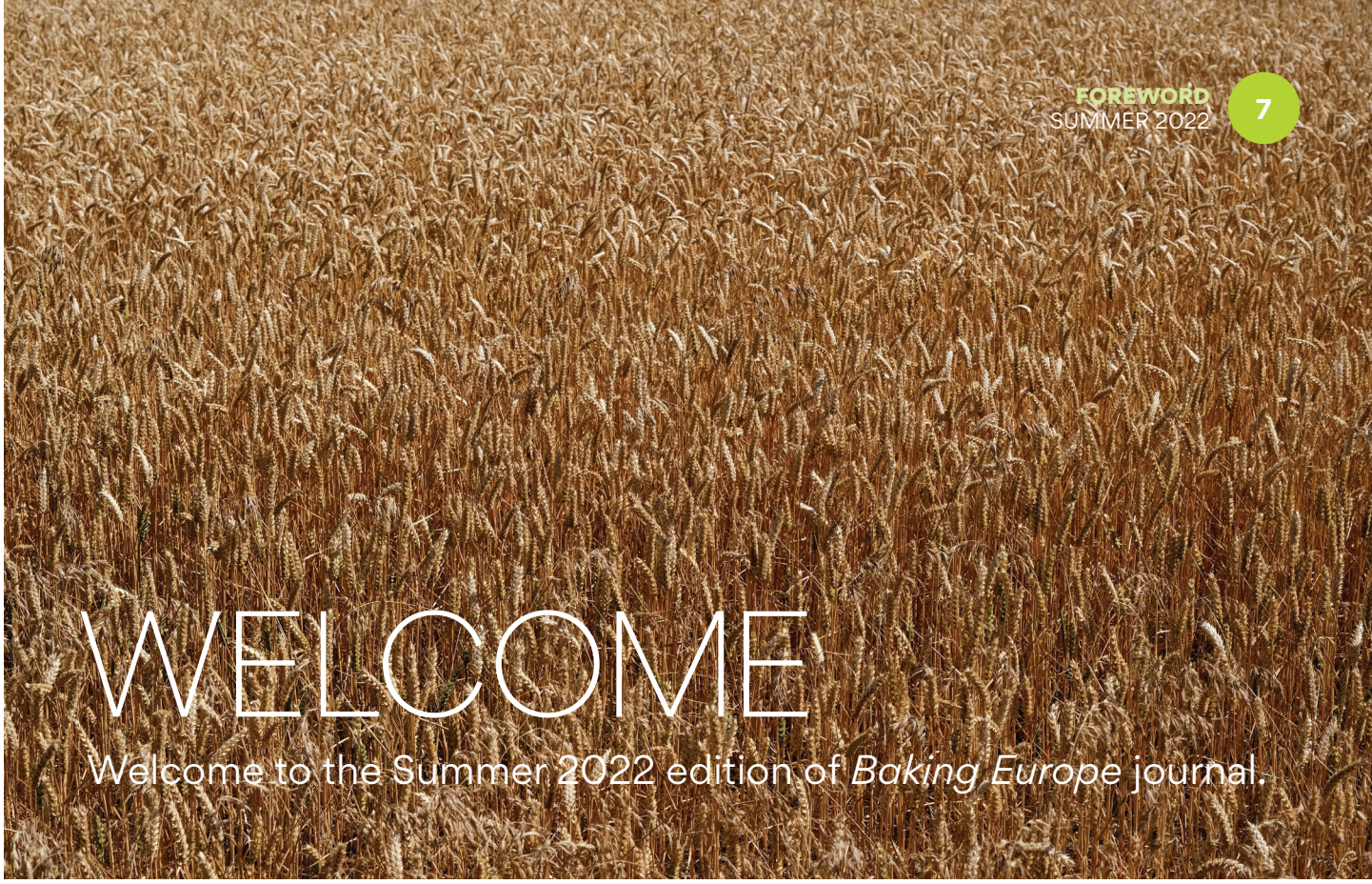




WELCOME

Welcome to the Summer 2022 edition of *Baking Europe* journal.

Early to bed, early to rise? You're probably a baker! In the summer of 1998, I remember catching the red eye back from Lyon, France. Well before sunrise, whilst walking to the bus stop where I would catch the 'navette' to the airport, my eye caught the only bright light and movement I would see before the bus arrived – in the bakery! There, a man was busy setting up shop for the day's customers and it dawned on me: it takes not only skill, but a lot of commitment to be an independent baker.

I expect that man has long since retired, but who might he have found to take over from him? Evidence from the 'Zero to Five' Food Industry Centre at Cardiff University suggests there might not have been many candidates to choose from. According to their article, attracting and retaining young talent in the industry is more difficult than ever. See P56 to get their well-informed take on future industry challenges relating to recruitment.

Whilst I may not remember the cost of a baguette in France 24 years ago, I do remember that it didn't change much during the entire year I was there. In my foreword to this year's spring edition of BE, I noted how the increased cost of bread was headline news. Now with inflation hotting up and the cost of living very much in focus in the media, the unsurprising bad news is that the bakery sector is also feeling the heat, in the form of input costs. The good news? This edition features some cool cost cutting ideas: Durrer's vacuum cooling systems featured on P48 will optimise efficiency and save money on any baking process and Pro4bake's article on P43 shows how their powerful platform can streamline a bakery by using its data to enable more efficient production. Finally, Portugal based CIMO Research Centre highlight the many savings and environmental benefits encapsulated in the concept of circular economy.

And if you think that business costs are far more important a consideration than environmental factors, our article on P39 is just for you! Experts at Digimarc demonstrate how products and their ingredients can now be tracked by 'digital twins' and how this means businesses that do not share the ideals of their customers or offer a tailor-made shopping experience, may not only suffer inflationary costs, but also decreasing revenues! That may not sound good, but our article on cutting edge sonication on P8 certainly does and with an in depth look at the use of gums in baking on P14 the BE summer edition has something for every industry professional.

There are now several bakeries on the road to that bus stop in Lyon, which one I saw is impossible to say, but I hope they are all reading BE. With costs mounting across the board and continued advances in money saving technology, whether you're a small or big business, you can't afford not to!

Richard Henderson
Sub Editor

COOKING WITH SOUND

Aiding food processing with Sonication to cook conserves more gently and to enhance long-life emulsified products

Written by:

Carmen Torres-Sanchez

Research lead of the Multifunctional Materials Manufacturing Lab based in the Wolfson School of Mechanical, Electrical and Manufacturing Engineering at Loughborough University (England)

Less energy-intensive, manufacturing processes that are more efficient with less waste and extended shelf-life have been a common goal for food manufacturers for decades. However, the climate-driven strategies imposed to help achieve net-zero, together with emissions targets, have made these pledges even more pressing for the sector over the next eight years. The European Commission has proposed a net greenhouse gas emissions reduction target of at least 55% in the EU[1].

Cooking processes can be very energy intensive as they require high temperatures and/or cooking for a long time. This is especially true for fruit and vegetables in order to produce jams, preserves and conserves, as they need to be cooked slowly with heat and steam. It is also true for producing emulsifications of dairy products and especially their plant-based counterparts, as it involves an energy demanding whipping process. Besides the carbon footprint these processes create and the environmental impact, the deterioration of nutrients, vitamins and freshness must also be taken into account.

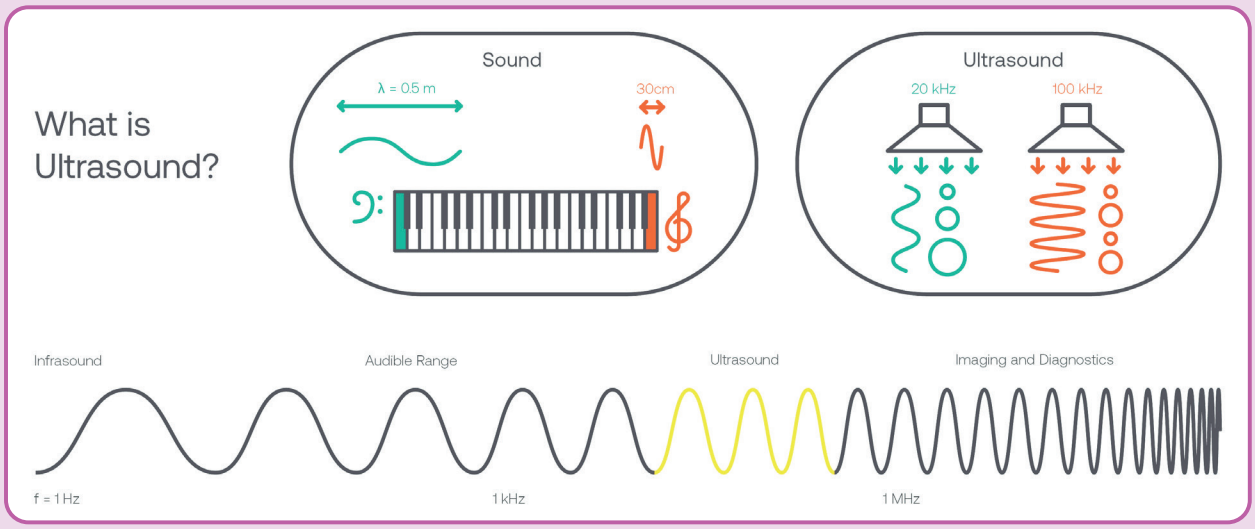
We have investigated how sonication can create more stable cream emulsions and provide a gentler cooking process for jams to retain more nutritional properties, using less energy and in shorter processing times.

The sonication technology has already seen a successful application in the aeration of edible baked foams, promoting gas generation during proofing as well as retainment of the porous structure during baking[2].

What is sonication?

Sonication is the use of ultrasound to aid manufacturing. The soundwave emits at 20-100 kHz and its energy enables it to interact with matter, altering its vibration state (Figure1). In this way, ultrasound aids emulsification and cooking processes. It is a technology that intensifies the aeration of blends and gives them long-term stability. It also enables cooking at lower temperatures while achieving the same chemico-physical reactions necessary to deliver the desired final product.

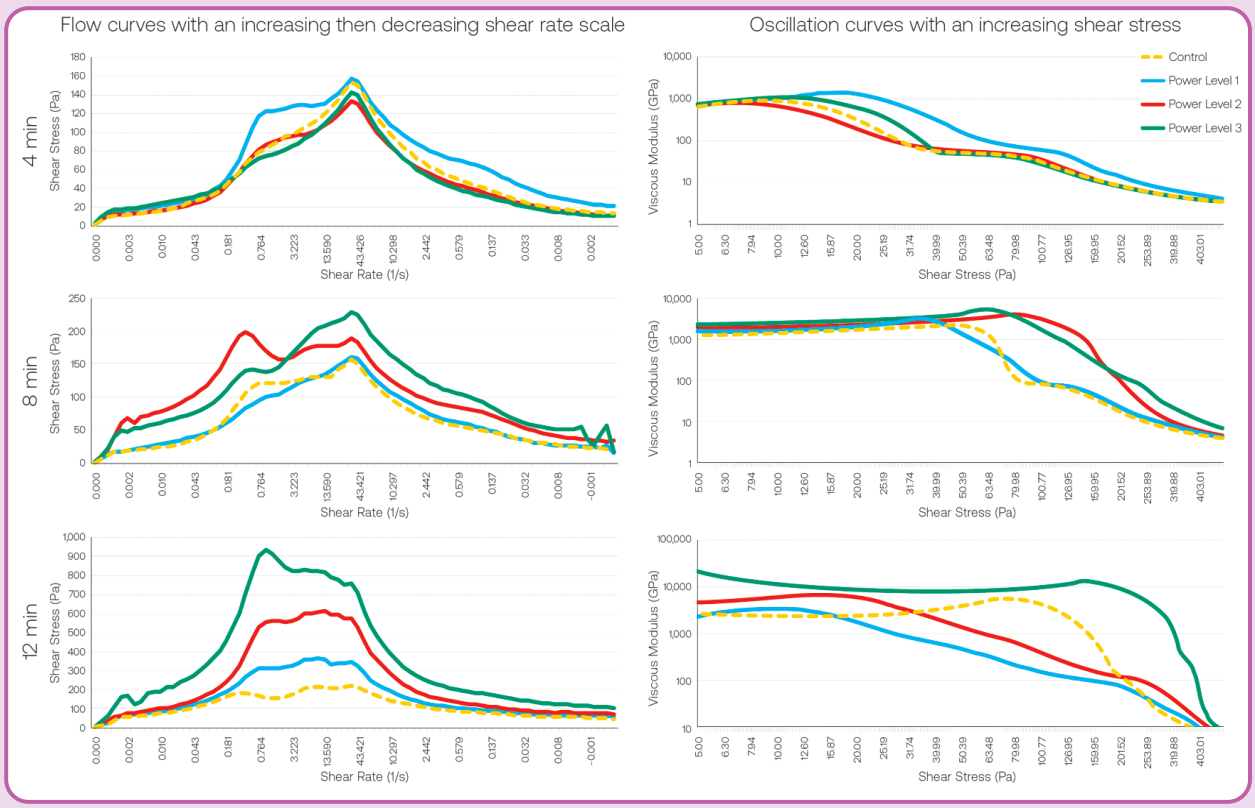
Figure 1: What is ultrasound. Ultrasound in plain waves



The benefits of sonication

The application of ultrasound to a food manufacturing process is non-contact and hygienic, which is of great advantage when considering food quality and safety. Since raw materials in the food & drink industry can be very sensitive to small variations in the cooking regime, this gentler technology offers the possibility of improving textures whilst retaining more nutritional attributes that are not diminished during the processing of the food. In addition, the lower temperatures and,

Figure 2: Rheological measurements of cream at different whipping times while exposed to sonication at different ultrasound intensities. A silent, non-sonicated sample is the control



therefore, the less heat input required, dovetail with a strategy of factory-floor energy optimisation, further enhanced by shorter processes.

Towards a net zero food industry

Food and drink manufacturers are constantly looking for new technologies and solutions to improve product quality, enhance nutritional properties and extend shelf-life.

A reduction in energy consumption in their processes, coupled with less waste, will allow them to reduce their carbon footprint and meet the targets imposed by the climate-driven National Strategy for Net Zero.

The decarbonisation of the Food & Drink sector requires that manufacturers identify emission-curbing opportunities, in particular those arising within production facilities[3].

We need to support companies that investigate new technologies and in that way lower the barrier to innovation in operational processes. Pertinent to small businesses, we ought to provide solutions that are easy to integrate and run, in an industrial setting and complement existing production processes.

"The application of ultrasound to a food manufacturing process is non-contact and hygienic, which is of great advantage when considering food quality and safety."

Emulsification of cream products has been improved with sonication
Sonication has a documented effect on the development of bubbles in foams[4]. Whipped cream is both a foam (a matrix of a liquid phase containing dispersed gas bubbles) and an emulsion (a product containing liquid droplets of fat dispersed in a second liquid phase -water). Its stability is positively correlated to a larger resistance to deformation when stirred and to a lasting 'gas-hold-up'. The whipping of cream is a time-consuming, energy-hungry process, and dairy-free plant-based products are more difficult to process, creating more waste when the target texture is not achieved.

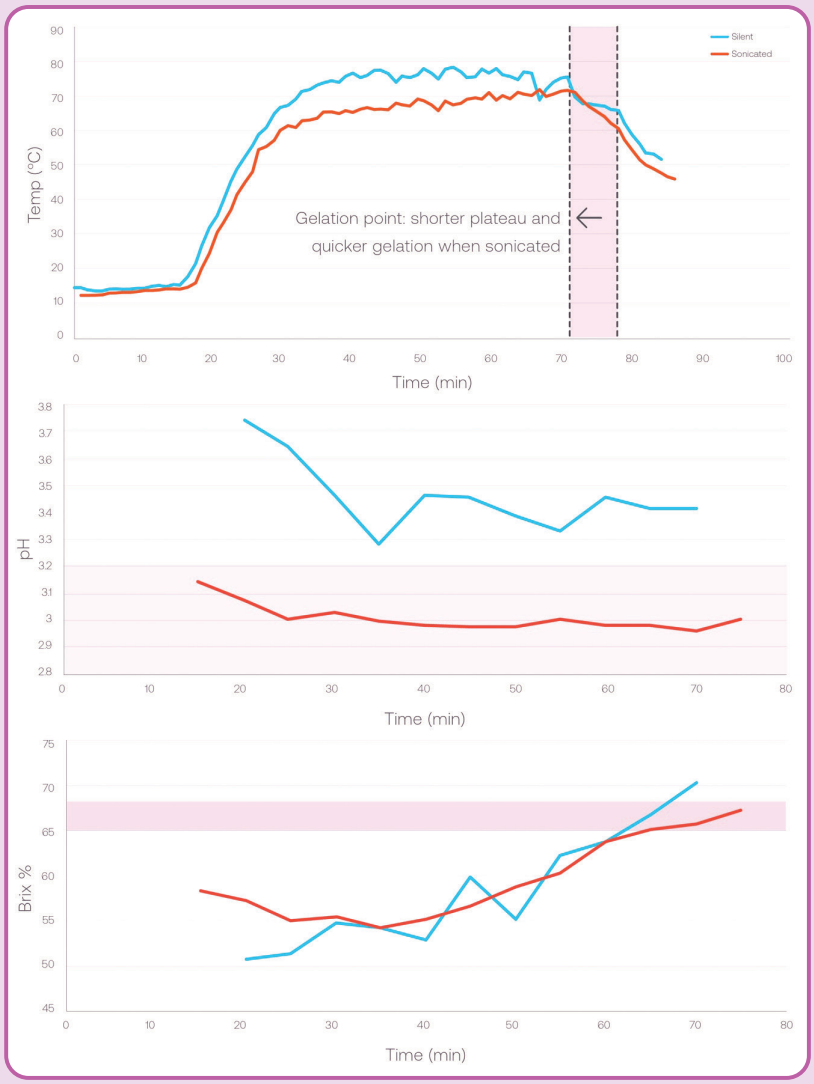
This study measured the variation of shear stresses (that is, how much the foam-emulsion deforms) in response to an increasing shear rate (how quickly it deforms in response) using flow curves. We also measured viscosity of the emulsion-foam at different shear rates (Figure2).

The results indicate that sonicated samples of whipped cream reached stability at a shorter processing time

"We have investigated how sonication can create more stable cream emulsions and provide a gentler cooking process for jams."

compared to the samples that were not sonicated during the whipping process (control samples) (8min when sonicated vs 12 min when silent). They also yielded larger viscosity when sonicated during whipping. Large values of shear stress and viscosity are indicative of a well-aerated product, a tight size distribution of droplets, a stable matrix and good levels of gas hold-up.

Figure 3: Evolution of temperature, pH and sugar content (in Brix %) over the duration of the cooking of plum jam



Furthermore, an ageing study up to 7 days shows that the emulsion is stable and sustains a good degree of gas 'hold-up' until day 7, when the bubbles coalesce under deformation. This is an improvement over the control sample, which coalesced after 2-3 days.

Preserving fruit is more efficient when aided with sonication

The cooking process of jams and conserves is also very energy-intensive, reaching high temperatures over long periods of time before gelation is achieved. Raw ingredients such as fruit and vegetables contain vitamins, probiotics and proteins that can be degraded due to over-exposure to heat, leading to a mismatch with the nutritional values reported on the label. Sonication allows a gentler cooking regime: it shortens the duration of the process and reduces cooking temperature, consequently preserving nutritional value in the final cooked conserve. The control of pH and sugar content in the final product is very important from a quality control viewpoint, as these two properties also conduce to gelation of the cooked fruit.

The sonication process has been reported to decrease peak cooking temperature by up to 8% (with temperatures below 72°C, an important threshold for the preservation of vitamins and to

prevent deterioration of other nutritional ingredients) and to shorten the reaction by up to 10 minutes, when gelation is achieved (Figure3). Sonication has also been useful in the control of pH and sugar levels in the cooking mixture throughout, with a tighter control over both, ensuring the final values fell within the required range (shaded regions in pH and %Brix graphs in Fig 3), despite variability in the raw ingredients.

Conclusions

Via the measurement of viscosity, texture and gas 'hold-up' using rheometric techniques, it has been demonstrated that sonication-aided cream whipping is quicker, the texture is firmer when sonicated and the shelf-life of sonicated-aided creams is longer. The cooking of fruit using sonication to produce jams and conserves requires lower peak temperatures and the gelation point is reached more quickly. These results indicate that sonication is a technology that can improve textures with more nutritional attributes and therefore enable a reduced processing time with less energy demand.

Author's biography

Carmen Torres-Sanchez is the research lead of the Multifunctional Materials Manufacturing Lab based in the Wolfson School of Mechanical, Electrical and Manufacturing Engineering at Loughborough University (England). Her research interests are in the manufacture of structures and textures with bespoke properties. This has driven the development of a technology to adjust the cellular structure of foodstuff via controlled ultrasonic irradiation (WO/2012/172353). She works at the biomaterials and engineering interface and collaborates closely with Industry.

Acknowledgement

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AN X IS JUST AN X

Written by:

Linda Bellekom-Allen

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X as a letter causes different reactions in different people. It's a kiss, a mathematical unknown, a horizontal axis, sometimes a yes, sometimes a no; or perhaps an incorrect answer.

To some people working in food, an X in a product's chemical name is an indication of something bad, suspicious, chemical, even unnatural. Hydroxypropyl methylcellulose and xanthan gum have both been tainted by this way of thinking. One wonders what these folks think about oxygen.

This article is about microbial exudates (another X!) and how to use them in baking.

Microbial exudates have a long history in food and medicine. Microbial life includes bacteria, fungi and yeast. These are sources of penicillin, amylase, lipase, protease and transglutaminase; all microbial exudates. Obviously, bakers are very familiar with yeast and amylase and many will know that sourdoughs's distinctive flavour and texture is as a result of bacterial fermentation and the exudates those bacteria produce. Similarly, we wouldn't have yoghurt or cheese, beer or wine without microbial fermentation. A lot of our most precious foods are made using microbial exudates.

The two main, food approved, bacterial exudates categorised as food gums are xanthan gum and gellan gum. There are others, but these two have gained traction in the market. One of the lesser-known ones, curdlan gum, is simply amazing but is not currently permitted in the EU, despite widespread food use in the Far East. Again, I am tempted to wonder about the mindset of scientists who create unfortunate names for bacteria. The bacterium from which curdlan gum is extracted is named: Alcaligenes faecalis var. myxogenes. So, a faecalis and an X make it unappealing, at least to the eye.

> "Xanthan gum is pH and temperature stable and has the yield point and suspending ability, whilst guar gum does not"

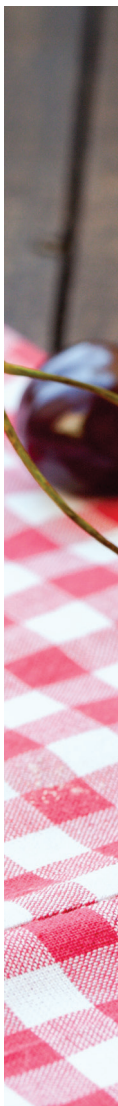
The chemistry of these gums are outside the scope of this article. Those who are keen to learn about this aspect of gums should either get in touch or consult Google. The information that I think is relevant to bakers, is about the functionality and uses of gums, including their tolerances, synergies and, sadly, what possible alternatives there might be when availability issues strike.

Xanthan gum

Named from the bacterium that produces it, Xanthomonas campestris, xanthan gum was discovered in the US in the 50s and approved by the EU for food use in 1974. It has the E number E415.

The usefulness and popularity of xanthan gum in food is based on:

- Cold and hot water solubility



- High tolerance to salts and low pH
- Consistent viscosity over a temperature range
- Suspending properties
- Synergies with other gums resulting in cost-effective thickening or gelation.

The downsides?

- Solutions are cloudy; some clear grades are available
- Mouthfeel can be... odd.

Cold and hot water solubility
Xanthan gum at 1% in water will give about 5000 mPas, which is thick, but not extremely thick.

Salt and pH
You don't normally find salt contents around 20% in food but if you did, most hydrocolloids would fail to thicken them. Xanthan gum, however, would thicken the solution, which is unusual, but not very useful unless you are making a salt crust. It takes slightly longer to dissolve at low pH but will retain its thickening ability across the range of pH 2 – 10. Again, unusual and this time, useful when you are working with fruits, tomato or vinegar additions.

Consistent viscosity over a temperature range
Viscosity should be considered in the context of a food environment, rather than by the information in the brochure. In xanthan gum solutions in de-ionised water the viscosity will change as the temperature rises. Add a small quantity of salt and it stabilises. In a food, with a wide variety of soluble salts naturally present, this means that the viscosity is stable from mixing through to end of baking, in dough and fillings.

Suspending properties
I've used xanthan gum to suspend hazelnuts, chocolate chips, jam and cherries in cakes. It does change the texture of the crumb, making it coarser, but the additions remain evenly distributed.

The suspending ability is due to xanthan gum solutions having a yield point, even at quite low concentrations e.g. around 0.1%. This means that you need to apply pressure to make them flow.

This property is very useful for suspending ingredients, preventing both settling and floating. Once stirring or shear is applied, the xanthan gum solution thins rapidly and flows, but as soon as the shear is stopped, it thickens instantaneously.

Cost effective thickening and gelation

A small amount of xanthan gum gives quite a good 'hit' of viscosity, thickening up doughs, batters, sauces, glazes and syrups. If mixed with guar gum, range 25/75 to 75/25, there is a synergistic increase in thickening.

Bear in mind that xanthan gum is pH and temperature stable and has the yield point and suspending ability, whilst guar gum does not. If you are looking to reduce costs, the combination should be cheaper as guar gum is usually cheaper than xanthan gum; though there will of course be two E numbers to declare.

In the same 'chemical family' as guar is locust bean gum: this interacts differently with xanthan gum to produce cold setting, rubbery gels. They do not have the same eating quality as gelatin but are similar in some ways e.g. melt on heating and a firm, rubbery texture. Tara gum, chemically a half-way house between guar and locust bean gum, forms a softer gel with xanthan gum. The high price of locust bean gum at the moment has led some people to use tara instead. I would expect the price to go up and availability down as a result.

Odd mouthfeel

The yield point of xanthan gum solutions means that it has to be forced to move. In the mouth, this presents as a strange, gloppy texture. I admit that is not a technical term – but imagine a liquid flowing in large drops from a container, rather than a smooth flow... glop, glop.

Addition levels

These will rarely be above 0.5% in a total wet mix when it is being used for thickening, water retention or suspension. In common with other water-soluble gums, it will not affect the water activity of a mix, it will affect the apparent water absorption of flour because it will thicken doughs and batters but, because it is water soluble, you should not look for a water absorption figure for it.

Addition method

As with all gums, xanthan gum is best either pre-blended with other dry ingredients before adding to liquids, or mixed with liquids it does not dissolve in like glycerol or oil, or high sheared into water. It will lump if simply added to water.

Alternatives?

Finding an alternative to xanthan gum really depends on what you are using it for and why you want to replace it. If it's for clean label reasons, then look to starch but don't expect the same result.

If it is for cost or availability reasons, then consider its function in your product. If it is just viscosity (thickening) try guar gum, cellulose gum or even starch or a blend of xanthan gum with guar.

2% solutions of 100%, 80:20, 60:40, 20:80 and 100% LA and HA gellan; solutions made cold then heated and cooled.

If you need low pH stability, cellulose gum will go as low as pH 3.2 area, methylcellulose and hydroxypropyl methylcellulose will go even lower. Pectin works better at low pHs and can be used to thicken without gelling, providing the sugar content is low.

If it is suspension that you need, HA gellan gum (see picture) and kappa carrageenan are options but both will be more expensive.

None of these will be straightforward replacements, as a result some functionality will be lost or added.

"Finding an alternative to xanthan gum really depends on what you are using it for and why you want to replace it."

Gellan gum
When gellan gum was introduced, its price was so outrageously high that I couldn't see it ever gaining sales. It has however found a place in the non-dairy sector, particularly plant-based milks, and in egg substitutes. In their literature, one of the suppliers mentions its use in icings, piping jellies, royal icings and 'non-standard' jams (probably low sugar).

Gellan gum was first approved for food use in 1988 (Japan), in Europe it has the E number E418. It is produced by growing the bacterium Sphinomonas elodea in large vats and extracting the exudate. Treatment with alkali removes acyl groups on the gum's backbone; two basic types are available, high acyl (HA) and low acyl (LA).

HA gellan is hot water soluble, so it is relatively easy to disperse in cold water. When heated to about 85°C, it will thicken; then, on cooling (to below 80°C) it will form a rubbery, flexible gel. This melts on reheating. If you high shear the gel during cooling, it forms a pourable, fluid gel. This network of tiny gels adds viscosity and suspending abilities and also gives a creamy mouthfeel. Hence their use in fortified plant-based milks, where the calcium salt may settle out if not suspended and presumably the piping jellies, royal icing etc.

LA gellan is a bit temperamental. It dissolves in deionised cold water but the presence of some salts stops this, however, this means you can disperse it easily in cold tap water. On heating to 75°C and above, it will dissolve. Once cooled, it forms a clear, brittle gel, that does not melt on reheating.

Interestingly, you can combine the two types to modify the textures of each. Pictured are gels formed from blends of LA and HA gellan. Note the change in opacity as HA is introduced and how the combined gel transitions from extremely brittle to flexible.

Addition levels
The usage level is very low in plant-based drinks, around 0.1 to 0.15% of HA gellan. In egg replacement it is higher, using the combination of both LA and HA gellan to obtain cold setting gels (think egg custard) and hot gels, (think scrambled egg).

If you are wondering about their use in egg replacement in cakes, I have not seen it... yet.

Alternatives to gellan
Originally gellan was promoted as a replacement for other gelling gums e.g. gelatin in petfood and carrageenan in chocolate milks. Its flexible, cold gel was also thought to be a good replacement for agar, carrageenan and gelatin in clear jellies. Availability is increasing as several manufacturers are now producing it. The main problem will still be the cost, as it is one of the most expensive gums on the market and to me, its unique properties are not yet fully proven in bakery.

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About the author

Linda is a specialist in hydrocolloids in food applications. As technical and sales support for cellulosics, working for Courtaulds then Dow, she developed a broad and practical knowledge of most food gums and how to assist developers in using them. She was instrumental in the incorporation of methylcellulose in plant-based foods and the dramatic improvement of texture in gluten free bread using hydroxypropyl methylcellulose. Now a consultant with Big Village Consulting Ltd. and an associate of Cybercolloids, she is not tied to any company or product range. She can therefore advise on hydrocolloid selection and use based purely on the developer's requirements. Linda is based in the UK and has a small development kitchen with lots of pots of gums.

GLYCEROL SHORTAGES

that will affect the bakery sector

Written by:

Gary Tucker

Fellow, Campden BRI

This article considers the supply difficulties with glycerol as an example of an ingredient that is being affected by major decisions and environmental disasters. The volatility of the global food oils market is having a knock-on effect on the cost of many ingredients derived from plants. Glycerol is just one such ingredient.

Why is glycerol important to baked goods production?

Glycerol, or E422, is a key ingredient in many food products because of its excellent ability to control water activity, which is important for extending product shelf-life. The bakery sector uses glycerol in almost all commercial cakes and in most soft textured products where shelf-life must be extended beyond a few days, e.g., cake muffins, cheesecakes, cookies and wraps. It is also used in icings to increase and maintain softness.

The key property of glycerol is as a humectant that can bind water chemically into the structure. This has two main advantages for extending the shelf-life of a product:

- Water is less abundant, so microorganisms such as bacteria, yeast and mould find it harder to grow. Packaged bakery products contain sufficient water to support mould growth and this limits their shelf-life. Glycerol is a powerful ingredient that can lower the product's water activity and extend its shelf-life before the visible signs of mould growth can be seen.

- Bakery products increase in firmness as they age. One of the reasons for this is the loss of water from the product. Glycerol makes it difficult for water to move within bakery products or to evaporate from product surfaces, helping to retain the soft textural product properties for longer into the shelf-life.

Glycerol shortage

Glycerol, which is also known as glycerin, is an ingredient with widespread uses across several sectors. About 25% of global glycerol production is used in food products, with an equal proportion for personal products, slightly less for oral products and various other uses including tobacco and pharmaceuticals.

In keeping with the laws of demand

and supply, a shortage in glycerol supply is causing its cost to increase sharply.

There are at least two related reasons why glycerol is in short supply and prices are rising accordingly. To understand why this is happening it is necessary to know how most of the global supply of glycerol is manufactured.

Glycerol is a by-product of biodiesel production, which is produced from vegetable oils, typically palm oil. About 80% of glycerol comes from biodiesel production, with 15% from oleochemical production and the remaining 5% from soap production. The biodiesel market is struggling because of the move towards electrification as an energy source for transport, combined with the desire to use vegetable oils for food applications. Hence the fall in glycerol supply. The food industry recently experienced a similar situation with carbon dioxide supply because of its production as a coproduct of fertiliser manufacture. As global manufacturers endeavour to make greater use of waste or coproducts, more of these supply issues are expected to arise.

The link with palm oil is the other reason why glycerol has increased in cost sharply. On 22nd April 2022, Indonesia imposed a ban on palm oil exports to protect its domestic market at a time of rampant global inflation. The ban stood until further notice, in a move to address rising domestic food prices. On 23rd May 2022 that ban was lifted and the supply of palm oil into the global food market started to return slowly back to normal levels. The ban came at a time of immense pressure on the supply of vegetable oils into the global market (Table 1). The price of edible oils such as soy, sunflower and rapeseed is expected to rise because of unconnected supply issues with each of these oils. Tonnages of soya bean oil will be limited due to droughts in South America, rapeseed oil due to disastrous crops in Canada and sunflower oil because of Russia's war on Ukraine. The projected shortages of these oils will increase the pressure on palm oil.

With many food oils likely to be in

short supply until the 2022 harvests are available, food companies need to find alternatives to oil-derived ingredients for their products. Glycerol is one example of an ingredient that is manufactured from food oils.

Alternatives to glycerol

The main function of glycerol in bakery products such as cakes and wraps is to control water activity and extend shelf-life. Glycerol has powerful humectant properties because of its small molecular size, comprising three hydroxyl groups on the three-carbon chain. It is relatively inert in terms of its colour and flavour, which makes it suitable for food applications, from viscosity control in semi-solids such as cheesecakes, to texture in cakes. The humectant properties of glycerol were first quantified by Glover (1948) in work on confectionery (Table 2). The table shows a selection of ingredients with a range of humectant properties, expressed as sucrose equivalents (SE). This is a simple scale that allows comparison of the relative ability of an ingredient to bind water. Sucrose is considered to be the common sugar in baking and is given the relative value of 1.0.

Glycerol has a SE of 4.0 meaning it is four times as effective at binding up water than sucrose. It is clear from the table that the alternatives to glycerol are few. However, common salt, or sodium chloride, which is an ionic compound with a very high SE value of 11.0, would provide an effective alternative because it is not needed at such high levels as glycerol. But, there would be flavour changes that could affect consumer acceptance of the cake products and in addition, salt has been the subject of a series of Government guidance on its use in food products. Baking powder is another powerful humectant, but it cannot be used at high levels without affecting the texture, colour and taste of the food. It also contains sodium which may present a problem for certain food types such as crumpets and wraps.

Other glycerol alternatives include sugars such as fructose and sugar alcohols, such as sorbitol. Neither have the powerful humectant properties of glycerol, but they are both better than sucrose at controlling water activity.

Table 1: Global shortages of selected food oils

Oil	Reason for global shortages
Soya bean	Droughts in South America affecting 2021 harvest
Rapeseed	Droughts in Canada affecting 2021 harvest
Sunflower	Ukraine war with Russia limiting planting in 2022
Palm	Indonesia banned palm oil exports from 22nd April until 23rd May 2022

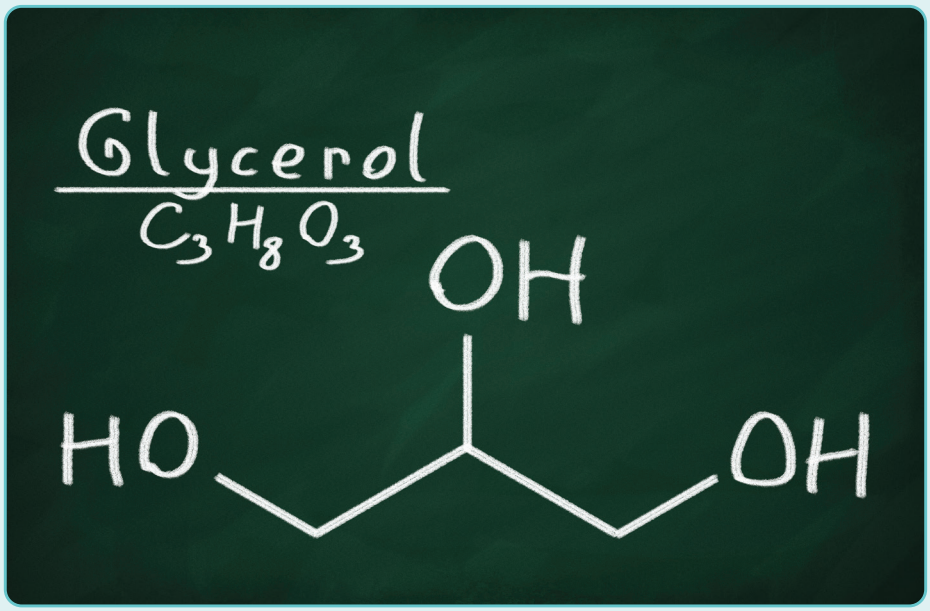
Table 2: Relative humectant properties, expressed as sucrose equivalents

Ingredient	Sucrose equivalent (SE)
Sucrose	1.0
Salt	11.0
Glycerol	4.0
Sorbitol	2.0
Milk Powder	1.2
Dried Fruit	0.9
Butter	0.2
Baking Powder	3.0
Fructose	1.4
Flour	0.2

Their proportion in any given recipe would need to be increased compared with glycerol. Fructose will certainly change the sweetness profile of a bakery product because of its intense sweetness profile compared with glycerol. This would require some recipe balancing to achieve the desired humectancy, texture and flavour properties.

An alternative approach to humectancy control with glycerol alternatives is to control mould growth using preservatives. This does not address the abilities of humectants to retain water into the structure over the shelf-life and so the retention of softness over shelf-life may well cause problems. Sorbate, for example, is a good mould inhibitor and used in some cakes and bakery products, where extended shelf-life is required. Long-life packaged croissants are one example of a product that uses sorbate for mould control.

Sorbate requires slightly acidic conditions to work effectively. Without acid, the sorbate remains in its salt form, but by adding acid, this moves the equilibrium towards the sorbic acid form, which is the active preservative. Using sorbate will require acids to be added to the recipes, which could give negative taste implications for cakes. The levels of preservatives such as sorbate, benzoate and propionate are controlled within EU legislation for food products.



The future

Glycerol is one example of an ingredient that is currently difficult to obtain because of supply shortages of raw material food oils, coupled with reduced demand for biodiesel, from which it is a byproduct. The supply issues with food oils that make glycerol will hopefully be resolved as we move further into 2022 and new oil plant harvests become available. However, relying on glycerol as a coproduct of biodiesel production is likely to become more limiting as the move away from fossil fuels gathers speed. The supply of glycerol may never return to what it was prior to 2022. This will force the glycerol price to increase and may cause some companies to seek alternatives or to reduce the quantities used.

> "Relying on glycerol as a coproduct of biodiesel production is likely to become more limiting as the move away from fossil fuels gathers speed."

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FOR MORE INFORMATION →

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food and drink innovation

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HOW TO ADOPT EASILY

both whole and enriched grain foods healthfully into your diet

Since our inception in 2004, the Grain Foods Foundation (GFF) has become a trusted advocate for all grain foods, whole and enriched. GFF has established itself as a science-based source of grains nutrition information, in part by building a respected wealth of published and peer-reviewed nutrition research, as well as by investing in successful partnerships with a diverse group of experts in the field of nutritional science. Our work to make the science around grain foods nutrition accessible is a core objective; we want to encourage people to enjoy grain-based foods and feel confident in their food choices. By choosing grains, individuals are feeding their families the foods that best serve as vehicles for good nutrition, especially when paired with other nutrient-dense foods.

With our nutrition research and experts on hand, GFF's mission is to lead the way in sharing the message that increasing whole grain consumption does not mean reducing enriched grain consumption. In recognising the nutrient contributions of both grain food categories and then pairing them, consumers will receive the best in nutrition from the grain foods they already love. The "Better Together" campaign promotes simple ways for consumers to adopt both whole and enriched grain foods healthfully into their diets to maximse flavour, variety and nutrition opportunities.

Using the motif of mixing and matching, "Better Together" was created to convey the positive

"'Better Together' inspires and celebrates grain-based foods as an important part of our everyday diet."

message that when whole and enriched grains are combined, consumers get even more nutrition than when limited to one food group or the other, including key nutrients such as dietary fibre, several B vitamins (thiamin, riboflavin, niacin, and folic acid) and minerals (iron, magnesium, and selenium).[1, 2]

Here are a few useful mix and match examples you may like to try:

- A fun "checkerboard" sandwich made with half enriched white bread and half whole wheat bread layered with your favourite low-fat meat and colourful, crunchy vegetables.
- Pair one slice of enriched garlic bread with whole-wheat pasta garnished with your favourite sauce.
- Wholegrain/enriched cereal combination served with milk and fruit. cereal topped with milk and fruit.

Additionally, "Better Together" inspires and celebrates grain-based foods as an important part of our everyday diet, especially when paired with other nutritious players on the plate – vegetables, fruits, low fat protein foods, or dairy – this creates nutrient dense and often cost-conscious meals. When you think about a meal for breakfast, lunch, or dinner, grain foods are foundational vehicles for so much nutrition – and tradition! – in consumer diets.

- Sandwiches are an excellent way to increase grain consumption, while also delivering vegetables and high quality proteins.
- Pasta pairs well with a sauce packed with vegetables and a sprinkling of cheese. Lean chicken, beef, or seafood makes it a complete meal unless you are a vegetarian, for example.
- Rice creates the perfect foundation for a colourful stir-fry of vegetables, protein and sauce.
- Ready-to-eat cereal or oatmeal can make for a very healthy snack when eaten with milk and topped with your favourite fruit.
- Pizza crust is a means of bringing all food groups together in one complete meal – ham, cheese, pineapple and tomato sauce make a delicious Hawaiian pizza.

There are so many ways to combine nutritious grain foods with other delicious, healthy foods, with simple creative food choices. The opportunities to benefit from grains are endless!

FOR MORE INFORMATION →

GRAIN FOODS FOUNDATION

Erin K. Ball
Acting Executive Director
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Common and Tartary BUCKWHEAT for innovative baking and better consumer health

Written by:

Ivan Kreft

Professor Emeritus of Ljubljana University, Slovenia

History and geography of buckwheat

The oldest known written reference to buckwheat bread dates back to 1689,[1,2] in Slovenia, but common buckwheat (*Fagopyrum esculentum*) has been cultivated in Europe since at least the 14th century, originating from an area in the Himalayan mountains. After the decline in its cultivation during the middle of 20th century, interest in growing and consuming buckwheat is now on the rise again, all across Europe.

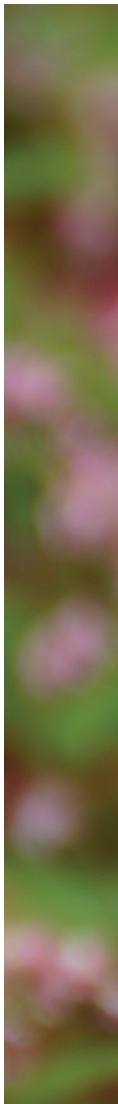
Buckwheat is also eaten in Japan, Korea, China and Bhutan, mainly in the form of pasta ("soba" in Japan), but some buckwheat pasta tradition exists in Europe, mostly in the southern parts of the Alps in Slovenia, in Italy ("pizzoccheri") and in France ("crozets savoyards"). In central and eastern Europe, it is traditional to eat husked buckwheat ("kasha").

Tartary buckwheat (*Fagopyrum tataricum*) is a semi-wild relative to common buckwheat. It also originates from an area around the Himalayas and is traditionally grown in mountain areas of China, Bhutan, northern India and Nepal, predominantly in high altitudes, in poor soil and in other harsh environmental conditions. In these countries, in regions with less severe climatic conditions, Tartary buckwheat is grown along with common buckwheat. In Europe, it is traditionally cultivated and used in Luxemburg and in adjacent areas across Belgium and Germany, with some use in Slovenia and Italy. In central Europe, to a large extent, Tartary buckwheat has been cultivated since at least 1816, when, in the "year without a summer", (due to activities of the Tambora volcano) other crops failed: Tartary buckwheat was the only crop resistant to the low sunlight conditions caused by volcanic ash. In terms of intrinsic qualities, Tartary buckwheat grain and milling products are rich in antioxidants, containing about 50 times more flavonoid rutin than common buckwheat.

> "Foods made from buckwheat grain have been shown to have preventive effects against several chronic diseases."

Preventive effects of buckwheat foods

Foods made from buckwheat grain have been shown to have preventive effects against several chronic diseases, including obesity, cardiovascular diseases, gallstone formation and hypertension[1,2]. The effects are mainly attributed to the digestion resistant starch, proteins and phenolic substances, especially flavonoids, in the grain. Rutin and other flavonoids have an impact on protein digestibility after hydrothermal treatment. Their interaction reduces the digestion of protein through the small and large intestines[3,4,5]. Microbial processes in the colon enhance the digestibility of the grain protein and starch, which are otherwise blocked by polyphenols in hydrothermally processed buckwheat. Buckwheat protein can



reduce serum cholesterol levels through the increased fecal excretion of steroids, which is induced by the binding of steroids to undigested protein. Digestion-resistant peptides are largely responsible for bile acid elimination. Furthermore, as buckwheat does not contain the gluten proteins, it can be consumed by people with coeliac disease.

The balanced amino-acid composition of buckwheat proteins also represents an important source of dietary protein for people who maintain vegetarian or vegan diets. Resistant starch acts as a dietary fibre and functions as a prebiotic. Furthermore, based on its origin, Tartary buckwheat is a low input plant. Due to its content of flavonoids and other phenolic substances, Tartary buckwheat is resistant to plant diseases and damage by UV-B radiation. This makes it possible to grow Tartary buckwheat as an organic and ecological crop, with little need, or no need, for the addition of artificial fertilizers, or chemical treatments.

Bitter taste of Tartary buckwheat

Milling the grain of Tartary buckwheat and mixing flour with water results in the formation of quercetin, as a degradation product of rutin by rutinosidase[6].

However, hydrothermal treatment of buckwheat flour or dough can be used to inactivate the rutin-degrading enzymes in buckwheat flour in a short time[7,8,9]. In any case, the formation of quercetin does not pose a problem in relation to the health of consumers as quercetin has similar effects as rutin.

Ingested quercetin has the ability to cross the blood–brain barrier and accumulate in the brain tissue[10]. Indeed, important bioactivities have been established for quercetin and its derivatives, not just in blood vessels, muscle and the gastrointestinal system, but also in the brain. Quercetin and other phenolics have been isolated from the stool samples of people who have eaten food rich in phenolic substances[10] and it has been demonstrated that the presence of phenolic substances in the colon can reduce virus loads in stools.

It is also possible to prevent the bitter taste of quercetin by hydrothermal

treatment of buckwheat dough, or by breeding Tartary buckwheat varieties without the active rutin degrading enzyme[6]. However, European consumers tend to accept the bitter taste when they are aware that the bitterness is due to natural health maintaining substances. In a similar way, many European consumers tolerate the bitter taste of chicory salad, beer, and other bitter tasting foods or drinks, so, why not accept the pleasant, but bitter taste, of Tartary buckwheat?

Buckwheat bread

Common buckwheat dough must be made from scalded buckwheat flour to be of acceptable quality, but, Tartary buckwheat flour should not be scalded to get optimal quality of dough and bread. Buckwheat bread is normally made with about 30% buckwheat flour, the rest being wheat flour. One possibility is to make buckwheat bread dough with the addition of Tartary buckwheat groats (kasha). In such a case, it is best to use buckwheat kasha obtained by traditional technology to husk pre-cooked buckwheat grain, a useful tip for those interested in making the bread: good buckwheat bread can be obtained by adding walnuts. It is also possible to make reasonable gluten-free buckwheat bread by adding chia or psyllium into buckwheat dough, instead of using wheat or rye.

Tartary buckwheat sourdough bread

Tartary buckwheat bread (Figure 1) can be prepared by mixing Tartary buckwheat flour (300 g), rye flour (100 g), wheat flour (600 g, semi-white, with about 0.75 to 0.90% ash content), sour dough starter (60 g), fresh baker's yeast (8 g), a pinch of salt and about 800 g water (or as much as needed). The mixture is allowed to rise for 12 hours at room temperature (about 25°C) and then for a further 12 hours at about 9°C and finally for another hour at about 25°C. It is baked in greased baking

> "This makes it possible to grow Tartary buckwheat as an organic and ecological crop."

form in a fan assisted oven for 30 min at 250°C and for a further 15 min in the same oven at 200°C. This recipe can be adapted according to the properties of the flours used, or by the baker's experience and consumers' expectations. The bitter taste of Tartary buckwheat bread creates a decent bread, but with less salt.

Lastly, buckwheat phenolic compounds can inhibit fungal development due to the phenolic hydrophobic interactions with cell membranes[11]. This effect is important for the antifungal properties of sourdoughs. Lactic acid bacteria can split flavonoid glycosides to flavonoid aglycones and sugar, and can further metabolize aglycones. The resulting metabolites, which include lactic acid and other organic acids, also serve to increase the antifungal activity of buckwheat sourdough. This might explain the prolonged shelf life of sourdough bread that contains Tartary buckwheat.

FOR MORE INFORMATION →

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Biography: Ivan Kreft is Professor Emeritus of Ljubljana University, Slovenia. Besides teaching in the class of food habits, he is a project leader at Nutrition Institute, Ljubljana. Kreft was visiting professor at Kyoto University (1992-1993), at Faculty of Nutrition, Kobe Gakuin University in Japan, and at Shanxi University, Taiyuan, China. He has conducted experimental studies on the nutritional value, quality and product development of buckwheat, spelt, barley and pumpkin seeds in Slovenia, Sweden and Japan. He has co-authored many papers and several books in Slovenian, German and English.

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INDUSTRY RESEARCH

Carefully selected research and science papers from company research departments.

In this issue:

By Vivgran
Trying Tritordeum, the ingredient that will enrich any baked product

By Digimarc
Digital technology: enabling businesses to tailor their customers' experiences

By Revive
Creating palm oil alternatives from used coffee beans

Bread-making and organoleptic benefits of TRITORDEUM and other gluten-containing cereals

Written by:

Etienne Vassiliadis

Co-founder and CEO, Vivagran

The origin of Tritordeum and other gluten-containing cereals
Tritordeum is a new species of gluten-containing cereal, an inter-species hybrid between a durum wheat (AABB genome), and a wild barley of Latin American origin (HchHch genome). Two parent crops were crossed in the early 1980s at the Spanish Public Research Institute. The initial goal was to combine the good functional properties of wheat with the climate change resistance properties of barley. The new crop, called Tritordeum (x Tritordeum martinii A. Pujadas (Poaceae) nothosp. nov), with genome AABBHchHch , has been on the market in Europe since 2013 and two commercial varieties are currently in cultivation.

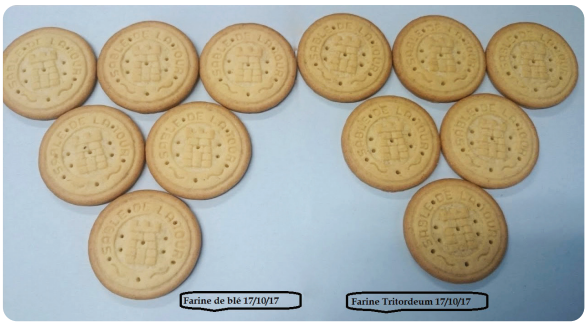
An active breeding programme in Córdoba crosses and selects new lines of Tritordeum each year, with the objective of selecting those with qualities suitable for baking, as well as for making pasta, or brewing.

Applications for the Bakery Industry
As with any other gluten-containing cereal, Tritordeum is ideal for baking bread. Its visco-elastic properties are good enough to bake it at 100% in any type of bread, in both direct or retarded proving processes.

Apart from bread, other applications include yeast leavened doughs, such as brioche, laminated dough like croissant, chemically leavened doughs, (cake, sponge, biscuits, etc) or other leavened, savoury doughs such as pizza, focaccia, etc, are all possible with Tritordeum flour.

In each application type, Tritordeum will enrich the recipe and quite often enhance health-related properties. In sweet doughs, rich in fats, eggs and sugar, this flour can be used to reduce quantities of these three ingredients and thus improve the nutritional profile of the baked product.

Baking trials performed by professionals on biscuit and cake products have shown that a reduction



Biscuit


Sandwich bread


Brioche

Baguette

of up to 10% in these three ingredients is possible without compromising colour, taste or mouthfeel.

When used as either partial or complete replacement for standard wheat flour, Tritordeum flour considerably improves the visual aspect and palatability. The pictures below show examples of products baked with 100% common wheat flour, compared to those with 100% Tritordeum flour.

Tritordeum and other gluten-containing cereals

Tritordeum belongs to the group of gluten-containing cereals including bread wheat, durum wheat, spelt, rye, barley, as well as "ancient" types such as einkorn or emmer.

Figure 1 Genealogical tree of cereals helps locate each of them in the evolution of the crop species:

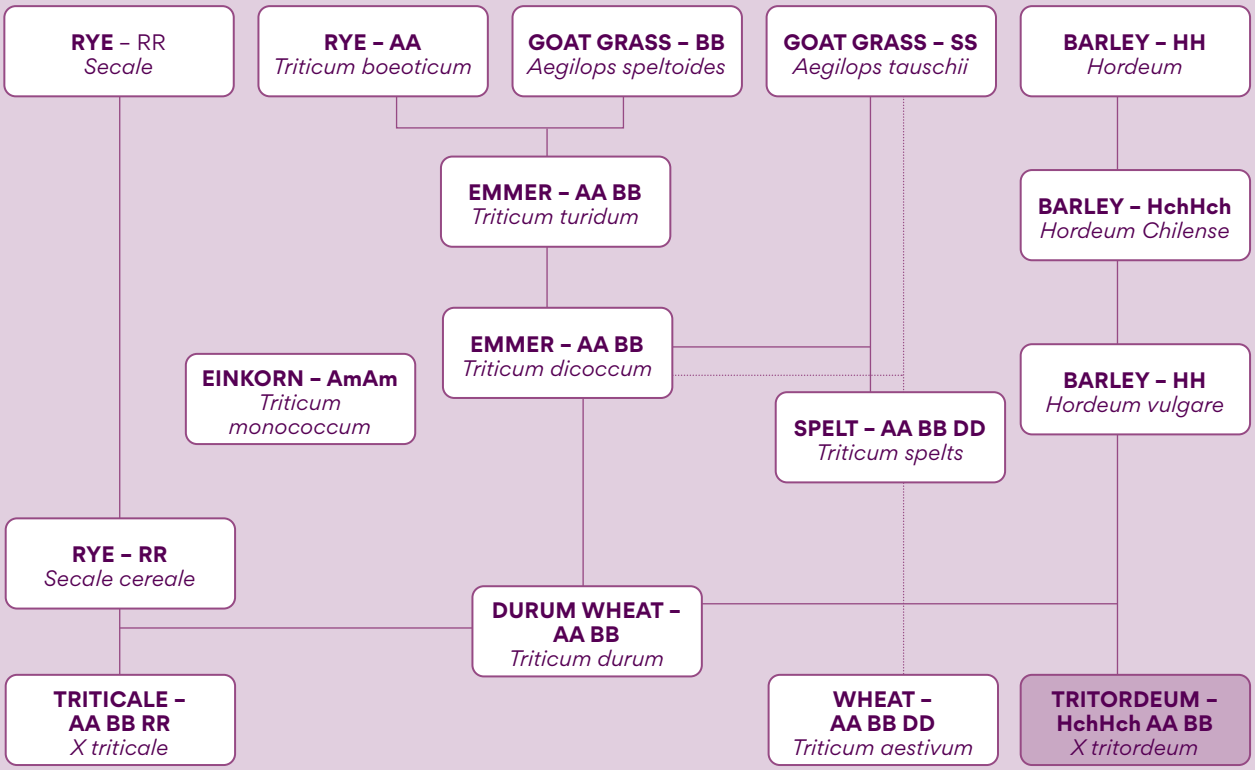
Triticale and Tritordeum are the only two man-made inter-species hybrids commercially available.

Triticale was produced nearly 150 years' ago, but due to its inferior baking and functional characteristics, never reached the food market for humans, although it is used today in the feed industry and as forage.

Tritordeum was produced some 40 years' ago and, thanks to its excellent baking and nutritional characteristics, it is the first man-made hybrid cereal to enter the food market.

"Tritordeum will enrich the recipe and quite often enhance health-related properties."

Figure 1



With the exceptions of barley and triticale, all other cereals are suitable for baking, however, each of them requires disparate methods of processing due to the distinctive differences in composition and morphology of the flour types produced after milling and their resultant, individual nutritional profiles. The ancient diploid and tetraploid species such as einkorn, emmer and ancestral durum wheat, are considered by professionals and consumers to be more healthy and richer in micro and macro-nutrients.

Conversely, the healthiness of modern hexaploid wheat is being brought into question by consumer concerns about gluten intolerance and FODMAPS (fermentable carbohydrates) despite the sketchy scientific evidence for these perceptions not currently being fully clear.

The following study took a 360° approach comparing these gluten-containing cereals and their performance in bread making applications to highlight the similarities and differences observed between them.

Bread-making analysis
Description of the study
Samples of commercial flours of each type of cereal were collected in Spain and Holland, all of which were of cylinder-milled refined type, with the exception of the emmer flour which was stone-milled.

The flours were tested in a standard bread recipe with an adjusted baking process for each cereal. The initial baking session using a standard process, allowed for the detection of differences in baking behaviour for

"Tritordeum was produced some 40 years' ago and, thanks to its excellent baking and nutritional characteristics, it is the first man-made hybrid cereal to enter the food market."

Figure 2

Mixing step	Resting step	Shaping step	Second Proofing	Baked Bread
Time	Time	Behaviour of dough	Time	Crumb structure
Dough Temperature			50g dough ball volume	Bread volume

Figure 3

	Bread wheat	Durum wheat	Spelt	Einkorn	Emmer	Kamut®	Tritordeum
Flour	100	100	100	100	100	100	100
Water	70	75	65	70	75	75	70
Salt	2	2	2	2	2	2	2
Yeast	1	1	1	1	1	1	1

each flour in terms of water absorption in the dough and tolerance to: mixing; bulk proving and secondary fermentation. The processes were then repeated and adjusted in a second baking session in order to obtain the best bread possible in terms of volume, shape and crumb structure after baking.

The parameters analysed throughout the study were presented in figure 2

Cereals tested
The cereals tested were the following:

- **Bread wheat** – Triticum aestivum
- **Durum wheat** – Triticum turgidum
- **Spelt** – Triticum speltoide
- **Einkorn** – Triticum monococcum
- **Emmer** – Triticum dicoccum
- **Kamut®** – Triticum turgidum sp. polonicum
- **Tritordeum** - x Tritordeum martinii A. Pujadas (Poaceae) nothosp. nov

Bread-making recipe and process
All cereals were tested in a standard recipe based on flour, water, salt and industrial yeast.All flours were pure, without additives of any nature.

The table in figure 3 shows the recipes for each individual cereal.

It is worthy of note that the water content value for Spelt flour was reduced to 65% whilst that for each of Durum and Kamut® were increased to 75%.

The standard baking process used for the experiment is shown in figure 4.

General data:

- The trials were carried out using 2Kg of flour in the recipe
- The mixing was performed on a spiral mixer
- The final dough temperature was between 23°C - 24°C
- The standard bulk resting time was 60min
- The dough division - 500g portions
- The pre-shaping was manual
- The resting of dough pieces was 15min
- The shaping was manual in a "batard" shape 20-22cm long
- The second proving time depended on the final volume of the 50g dough ball used as control
- Baking was performed in a deck oven at 230°C for 35min
- The cooling was done at ambient temperature

Figure 4

Figure 5

	Bread wheat	Durum wheat	Spelt	Einkorn	Emmer	Kamut®	Tritordeum
Volume of a 50g dough ball (ml)	100	120	80	80	100	120	110
Time (min)	70	80	30	30	80	80	70

For the second proving duration, a time adjustment was necessary, since not all the cereals had the same tolerance. The table shown in figure 5 presents the volume of the 50g ball of each of the dough and the equivalent duration:

Results

Figure 6 shows the photographs of the various products being processed at different stages of production from constituent flour being used, doughs being proved and their subsequent shaped pieces, as well as breads and respective crumb structures.

It can be observed that the appearance of the various flours differs greatly: wheat and spelt portray a similar, off-white colours, Kamut® and durum have a light, yellow colour, whilst Tritordeum has a darker, yellow colour, Einkorn light-beige and emmer reddish-beige.

The particle size of Durum wheat and Kamut® flours is generally larger than those of other flours whilst that of the stone-milled Emmer, whilst having a higher bran content is not a strictly speaking, a wholegrain flour.

With respect to the doughs in the trials, bread wheat and Tritordeum behaved in a similar way, both requiring a mixing time of 10min at low speed. Durum wheat, emmer and Kamut® could be mixed 1min more quickly to reach an acceptable dough consistency, whilst spelt and einkorn being more sensitive to mixing duration required just 6-7min. Thanks to the water content adjustments made in individual recipes, all doughs presented a similar consistency after mixing, with the degree of degradation of the doughs during resting, due to enzyme activity and resultant gluten network strength, was highest for spelt and einkorn, in comparison to the other cereals.

In order to assess closely the consistency and gauge the structure of the dough in a testing environment, the employment all five

Figure 6

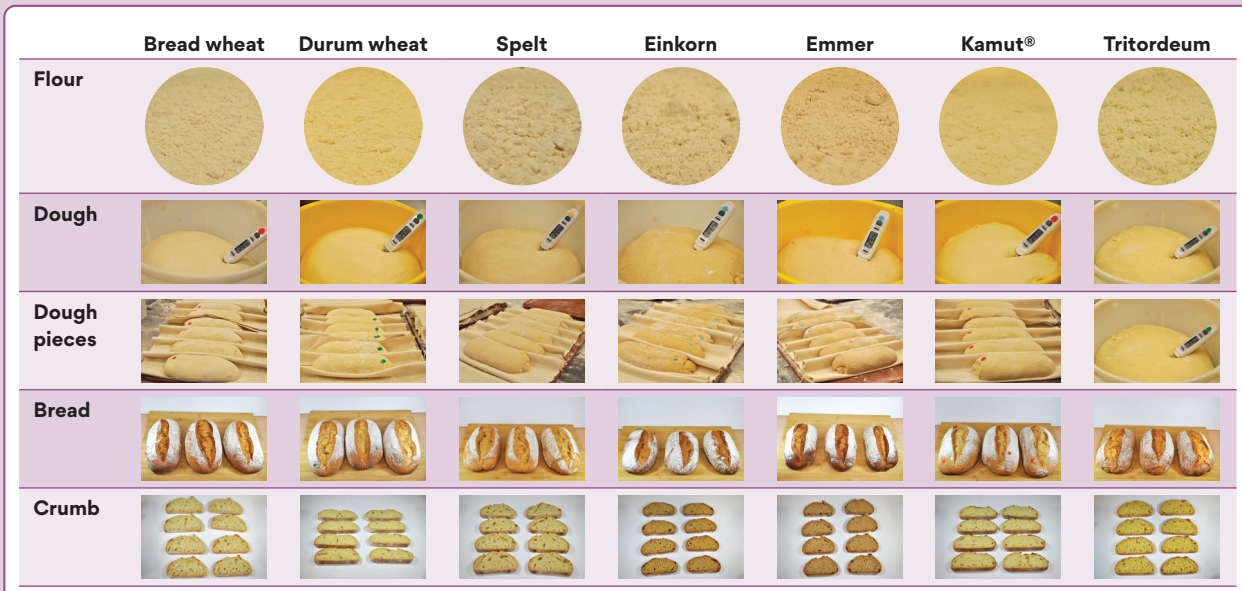


Figure 7

	Bread wheat	Durum wheat	Spelt	Einkorn	Emmer	Kamut®	Tritordeum
Mixing Time (min)	10	9	6	7	9	9	10
Dough Temperature (°C)	23.7	23.1	23.5	23.2	23	23.4	23.6
Resting Time (min)	76	64	72	71	64	64	78
Shaping behaviour	***	***	**	**	***	***	***
Proving Time (min)	72	78	28	28	78	78	70
Volume 50g dough ball (ml)	100	120	80	80	100	120	110
Bread Volume *(cm)	25.5	23.5	22	17.5	20	24.5	25

"Tritordeum stands out from other gluten-containing cereals thanks to its mild, yet distinctive flavour signature."

senses cannot be beaten by any machine, therefore, the shaping of the dough pieces was done by hand with all doughs behaving well without breakage or lack of tolerance.

The only two doughs that proved a little trickier were those made with spelt and einkorn, both of which presented slightly weaker strength.

The measurable data are presented in the table shown in figure 7.

*The bread volume was measured using a seed displacement mechanism, where the baked bread is immersed in seeds and the height of the seed measured on a ruler. The higher the seed level, the greater the volume.

As expected, durum wheat and Kamut® behaved in the same way during the baking process, Tritordeum showed a similar behaviour to bread wheat, Emmer behaved well in the baking process, but the final bread volume was low due to the fact that the flour contains a higher level of bran than that of the other flours tested.

In terms of volume, figure 8 presents the percentage of bread volume loss, when compared to wheat based bread:

Spelt, emmer and einkorn are the cereals with the lowest bread volume after baking.

Tritordeum, Kamut® and durum wheat are very close to bread wheat in terms of final bread volume, although differences in crumb structure can be observed.

When looking at crumb structure, bread wheat and Tritordeum present the most aerated crumb structure of

Figure 8

	Wheat	Tritordeum	Kamut	Durum wheat	Spelt	Emmer	Einkom
Volume	25.5	25	24.5	23.5	22	20	17.5
% of bread volume loss compared to wheat		1.96%	3.92%	7.84%	13.73%	21.57%	31.37%

Figure 9

	Wheat bread	Durum wheat	Spelt	Einkorn	Emmer	Kamut®	Tritordeum
Flavor/Taste	Mild, Cereal	Floury, slightly sweet	Mild, Cereal	Sweet, Nutty	Nutty, Toasted, Malty	Floury, Sweet	Sweet, Milky, Toasted, Nutty
Crust crispiness	Good, Thin	Excellent, Thick	Good, Thin	Good, Thick	Good, Thick	Excellent, Thick	Excellent, Thin
Crumb bite	Chewy, Soft	Short, Very firm	Chewy, Soft	Short, Firm	Short, Slightly firm	Short, Very firm	Short, Firm
Mouthfeel	Slightly dry, Easy to swallow	Moist, Doughy	Dry, Easy to swallow	Slightly moist, Easy to swallow	Slightly dry, Easy to swallow	Moist, Doughy	Moist, Easy to swallow

all the breads, with a lot of irregular crumb holes. Kamut® and durum wheat have denser and more regular crumb structures. Spelt presents a dense crumb structure with a few larger crumb holes. Einkorn has a rather dense crumb structure. Emmer presents the densest crumb of all the breads tested.

Figure 9 shows a description of the organoleptic characteristics of each bread type, as evaluated by the authors.

Tritordeum stands out from other gluten-containing cereals thanks to its mild, yet distinctive flavour signature. The sweet and milky notes dominate from the first moment that the flour meets the water during the mixing stage. The baked Tritordeum bread has a characteristic very crispy crust combined with a moist, firm, resilient and easy to swallow crumb.

Conclusions on baking tests

When tested in a standard bread-making process, each of the gluten-containing cereal flours behaved in a different way. Bread wheat and Tritordeum behaved similarly, while Kamut® and durum wheat gave denser crumb breads. Spelt shows less process tolerance, but gives a baked bread that looks similar to wheat bread. Einkorn and emmer give very different crumb colour and structures. The sensory profile of each grain type is what gives them their own personality, especially in the cases of einkorn, emmer and Tritordeum, where the added value compared with standard bread wheat is clearer.

General conclusions

Tritordeum belongs to the gluten-containing cereal group and as such is suitable for baking at 100%.

When baked at 100%, each cereal has its own personality, and some of them stand out for their crumb colour, open-crumb structure and sensory profile. Tritordeum behaves in a similar way to bread wheat, with a yellow aerated crumb and a good baked bread volume. Its taste and mouthfeel convert it into an added-value option to enrich bakery goods recipes, or for innovation in new healthier alternatives.

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CIRCULAR THINKING

Accelerating the shift towards a more sustainable bakery industry

Written by:

Scott Kennedy

Co-founder, Revive Eco

A new, sustainable alternative to palm oil made from used coffee grounds has now been developed in the UK. This natural oil has many applications in the bakery and wider food and drinks industries.

For many years, my co-founder and I worked in cafés across Glasgow, and we would finish each shift by taking bags of used coffee grounds (UCGs) out to the bin. From here, the coffee grounds would then end up either at an anaerobic digestion site or more often than not, a landfill site.

In the eyes of many, these UCGs were viewed as a waste material, a by-product from the creation of a cup of coffee. As we learned more about sustainability, the circular economy and innovation through our university studies, we quickly realised that this was not a 'waste' material. In fact, this was a classic example of a resource in the wrong place. Just because the grounds no longer have a use for a café or a restaurant certainly doesn't mean that they do not have a use elsewhere.

Fast forward 10 years and we have now developed an innovative process to create real value from these coffee grounds. Most importantly, these valuable outputs offer a plethora of industries with more sustainable, local and ethically-produced raw materials.

Over the last 12 months at Revive, we have developed a process to extract the natural oils from UCGs and we have successfully been able to replace palm oil derived ingredients with our coffee-derived oil in a range of products. We have removed the need for palm oil in muffins, skincare products and soap, to mention just a few examples.

We currently produce two versions of coffee oil, one of which is a rich, dark coloured oil, that we call native coffee oil and a decolourised equivalent. Both oils have an almost identical chemical composition to that of palm oil. There is also ongoing R&D into refining these oils into truly cutting edge materials, thus giving them greater functionality within products.

We are currently collaborating with a range of manufacturers in order to trial our various outputs within a range of products.

Global palm oil consumption is currently around 75.5 million tonnes annually[1], with the vast majority produced in Indonesia and Malaysia and then shipped to every corner of the world. Palm oil is a very versatile and high yielding vegetable oil, hence its wide use globally. However, as Sir David Attenborough and the WWF[2], amongst others, have highlighted, the growing consumption and production of palm oil has had catastrophic environmental consequences for the world as we know it.

Due to the global distribution of palm oil, we have seen increasing levels of deforestation, habitats destroyed, species taken to the brink of extinction and carbon emissions rapidly increasing. Rainforests are the lungs of our planet and by destroying them we are destroying the very ecosystem that we rely on for survival. Loss of the rainforest will lead to huge losses in freshwater, which will have catastrophic implications around the world. For example, from 2015-2017, the global loss of tropical rainforests contributed around 4.8 billion tonnes of carbon dioxide per year. This is equivalent to around 8-10% of the annual global carbon dioxide emissions created by the human race.[3]

The critical importance of reversing deforestation has recently been noted at COP26 in Glasgow, where 141 countries pledged to conserve forests and accelerate their restoration.[4] This included commitments from Brazil, Indonesia and Malaysia. The tangible outcomes from this pledge are very much up for debate, but this commitment from some of the largest contributors to deforestation is, at the very least, a step in the right direction.

Environmentally-focused solutions have the scope to be the real drivers of change. It is not a case of needing to reinvent the wheel, but rather looking around us to find materials which already exist to identify ways to

expand their lifespan. This in turn will help reduce and ultimately eradicate the need for the many different unsustainable resources we all currently consume.

In terms of circularity, what could be better than creating more sustainable processes all under one roof? If we consider bakeries that sell coffee, it would be a great success for the environment if such bakeries had the ability to use sustainable raw materials in their baked products which have been produced from the UCGs in their own stores.

There are two key challenges which circular companies such as ours must overcome before we can truly disrupt industries and create substantial positive environmental impact through collaborating with partners. These challenged are:

1. achieving a level of scale substantial enough for manufacturers to have the confidence in supply to shift to using our materials.

2. to be able to compete on price with existing raw materials.

We know that the baking industry and many other industries, want to change towards using more sustainable and local raw materials. The vegan steak bake is a testament to this ideal. We also know however, that this change will, by and large, not be done out of the goodness of the hearts of the manufacturers. It is imperative that we reach a substantial scale in order for us not only to supply the quantities needed in industry, but also to enable us to compete on price. This is the essence of the circular economy – if we are to realise our ecological goals, solutions must be both environmentally and economically sustainable.

A word often used, and quite rightly, in the quest to find solutions to climate change is collaboration. When shared motivations and objectives are coupled with joint thinking and ambitious plans, there is a huge opportunity to put the baking industry at the forefront of sustainability. Collaborations between companies like Revive and manufacturers can open up a world of possibilities and innovation which will make a real difference to the world we live in.

It is simply not enough to slow down whilst continuing along the same unsustainable path. We must change direction altogether, and quickly, in order to ensure irreversible damage is avoided.

> "In terms of circularity, what could be better than creating more sustainable processes all under one roof?"

FOR MORE INFORMATION →

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Scott Kennedy is a co-founder of Glasgow-based start-up, Revive Eco. Scott studied Entrepreneurship at the University of Strathclyde and is passionate about creating circular solutions to solve global issues. Scott has worked in a range of industries including hospitality and events and uses the great Scottish outdoors as the inspiration to protect the wider environment.

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IT'S TIME TO GET PERSONAL!

How digital identities offer huge opportunities for retailers

Written by:

Ken Sickles

EVP, Chief Product Officer, Digimarc

Winning and retaining customers in today's market is a much tougher task to achieve effective brand penetration than it has ever been in history. Gone are the days when shoppers make the same repeat purchase, simply because "it is what they have always done."

Shoppers are developing increasingly higher expectations from their favourite brands so it is no longer enough for businesses to run a catchy advert campaign or offer a give-away. Consumers want real evidence of alignment with their personal values; assurances that the products they are bringing into their homes and giving to their families are safely and ethically produced from manufacture to purchase. It's no longer acceptable for retail businesses to pay lip service to sustainability and ethical values, today's savvy customer demands proof.

Coupled with the need for evidence is an increasing expectation of personalised engagement where, for example, it includes offers and information tailored to the individual's needs. Recent examples of this personalised experience have been employed by Netflix and Amazon.

A recent article by analyst firm McKinsey[1] states that consumers are attempting to understand brands throughout the purchasing process and to engage with them, whether that be in-store or on-line, for a more tailored experience.

Today competition in this sector is fierce and brand loyalty has become a thing of the past, with customers ready to switch brands readily if another brand offers more competitive pricing, a better customer experience or more personalised engagement. Sustainability principles and ethics are increasingly higher decision-making factors, too. Brands need to ensure that customer engagement, along with adherence to brand promises across the whole of the product life cycle, is at the very heart of their business strategy.

How do brands deliver on these promises?

It can be described in one word, namely, data. Utilising such data

wisely to gain insights into a customer's preferences to offer a unique 'experience' is revolutionising the consumer packaged goods (CPG) world for both business and consumer which, in addition, is rendering greater trust, subsequent engagement and personalisation, which is achievable and realistic.

Going digital

Digital technology is revolutionising how we interact with the physical world. Every day, we are creating more and more digital representations of physical objects and phenomena. We are also starting to see new ways of using this technology to create "digital twins" of real-world objects and systems. Utilising digital identities is not a new approach, it being based on one of the oldest, most successful and, indeed, basic selling principles of all time; knowing your customer.

Digital identities are a key part of this new digital world. By giving every object and phenomenon a unique identifier, we can track it, share information about it, and even control it remotely. This is already having a huge impact on how we manage our physical world, and the potential applications are only limited by our imagination.

This means that businesses can gain greater visibility across the whole life cycle of their products, from the raw materials, manufacture, packaging and, crucially, the point of sale (POS) and beyond. By using digitisation where each product can be allocated a unique scannable code, businesses can ensure that the whole production process is proven to be safe, ethical, and sustainable.

Product digitisation also provides the capacity to supply information on the location and condition of goods, enabling manufacturers to be more confident of the handling of temperature sensitive goods, thereby enabling batches necessitating a recall to be more easily tracked and recovered than on many systems currently in operation.

It is clear that this strategy can allow for an enhanced level of confidence in brand promises. However, this innovation really comes into its own at POS in-store when a customer scans a product, or post-purchase when a direct connection is established that opens a door to a wealth of customer data, providing valuable insights into his/her purchasing behaviour.

This ability to gather data from pre and post purchase scanning and interaction means that businesses can access and utilise such information in a way that has never been previously possible. For example, every element of a product strategy can be honed to a specific audience, from sales location, in-store displays and distribution timing. It also means that brands can give consumers the personalised service and experience what they are craving, encouraging that ever elusive customer loyalty.

A typical illustration of this exercise might look something like this: a consumer scans a box containing a fresh cream cake using their phone giving them instant access to information on the ingredients such as their sustainability, production process (e.g. are workers treated ethically?) and transportation (has it been kept at a safe temperature?) the process encouraging manufacturers and retailers to follow through on the

promises to maximise consumer loyality, brand confidence and, therefore, future sales. This may be in the format of downloading an app to gain loyalty points/future discounts in line with the many loyality card/ discount systems currently in use, but enhanced by the easily accessable data on their mobile phones. Needless to say, this can lead to upselling, repeat purchases in addition to a signifiant improvement on strategy development owing to this heightended level of insight.

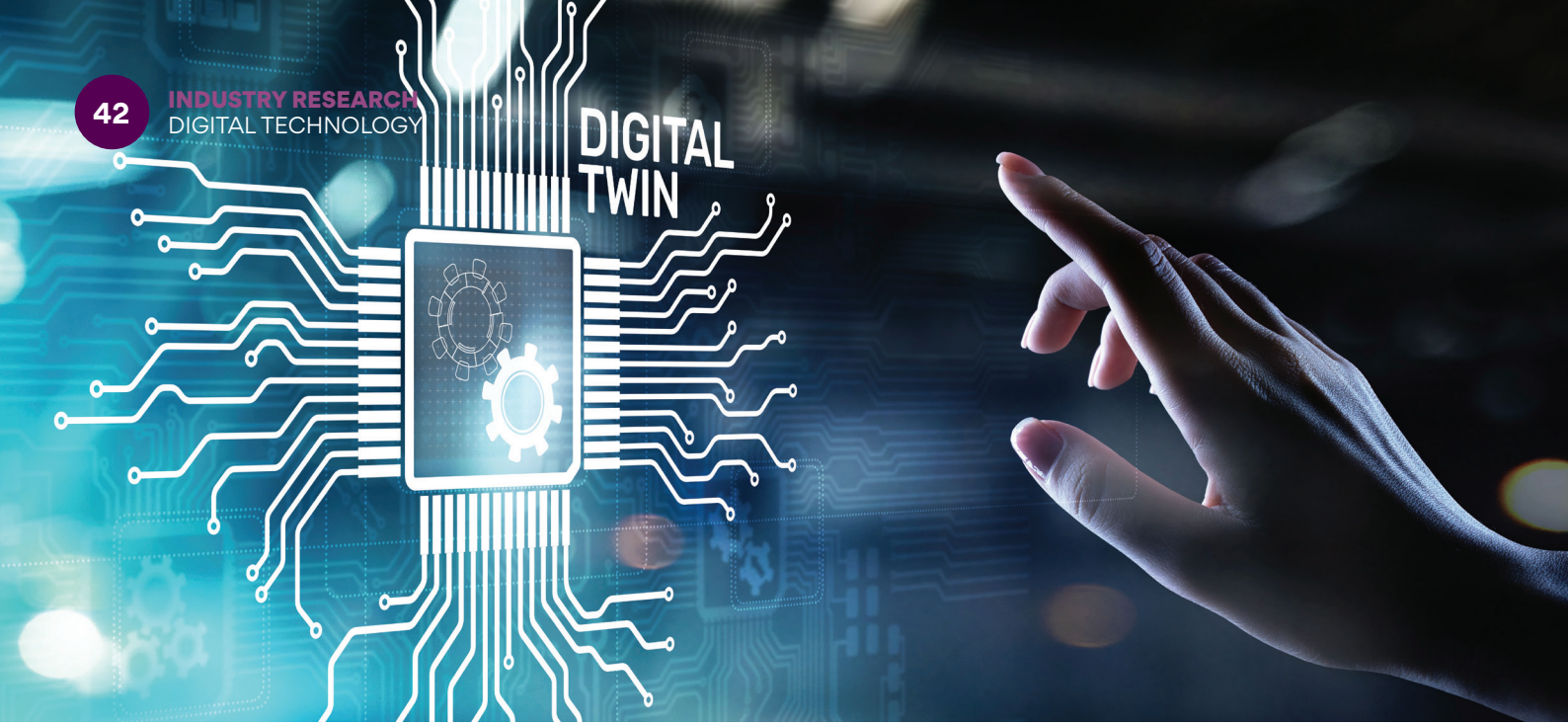
Tracing the trash

A further advantage of such a system is that it offers greater insight into what happens after a customer has finished with the product, such as the responbsible disposal of the used packaging. The European Union has proposed a number of long-term targets for landfilling and recycling, and by 2030, no more than 10% of municipal waste should go to landfill in the EU. In addition to this binding target, the new laws would include a total ban on the landfilling of waste which has already been separated and sorted for recycling.

> "New ways of using this technology to create 'digital twins' of real-world objects and systems."

The recycling and re-use of municipal waste must reach 65% in Europe by 2030, with a target of 75% set for the recycling of packaging waste. Specific targets for resource efficiency, plastics and food waste were left out, however the EU reiterated its pledge to meet the global Sustainable Development Goal of halving food waste by 2030.

It is imperative that producers play their part in reaching these goals, both to reach their own targets and to meet consumers' increasingly discerning behaviour and desires. Being able to engage with the consumer, and even educate them on how to dispose of, or even return the



packaging in the most appropriate way, demonstrates a firm commitment to achieving these goals.

Unexpected positive outcomes

The global CPG market is expected to be worth over US$15 trillion[2] by 2025, however a new report launched this month by Digmarc Corporation[3] who surveyed 2,000 UK consumers found that being able to verify that a product is authentic is now important to 73 percent of consumers with over half (59 percent) saying how and where a product was made is key to their purchasing decisions.

Until now, tackling this criminal activity and adultration has proved to be very difficult, with huge ramifications for brand protection and consumer health and safety, as well as the inevitable revenue loss and damaged reputation.

Digital identities can help to combat this issue by providing a way to track products throughout the supply chain and ensure that they are genuine. In addition, by linking products to digital twins, businesses can also keep track of where each product is in the life cycle, from raw materials to final disposal. This will allow businesses to make more informed decisions about their product ranges and make sure that they are only selling products that are safe, ethical, and sustainable.

The opportunity for businesses

Access to accurate, current, data on customers is an essential component of ensuring agility within a business, a need that is only going to increase in the future, particularly with Google's announcement that, by 2023, marketers will no longer be able to use cookies on its Chrome browser; a term that is being referred to as the "cookie-less future[4]." Without cookies to track easily consumer activity online, brands will need to find new ways to acquire consumer-facing data (McKinsey[5]). GDPR rules will of course still have to be rigorously ahdhered to.

With QR code scanning in its early maturity in major markets worldwide, those businesses who implement digital identities on their products have an unparalleled opportunity to gather meaningful metrics.

Conclusion

The digital identity revolution is already here. CPG companies now need to decide how quickly they will get on board and the level of investment they are willing to make into their data acquisition strategy.

Those that lean into this opportunity now will be the ones able to utilise data to capitalise on customer insight sooner rather than late, building loyalty and establishing a name as a brand that offers a personalised experience. Those that prefer a 'wait and see' approach may find themselves trailing behind in years to come.

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PRO4BAKE

A tool for bakers – developed with bakers

Written by:

Viktória Parrag

Development Engineer, Campden BRI Hungary

Digital transformation of the food sector. Why is it so complicated?

These days, digitisation is a popular buzzword. Increasingly and sometimes impercetibly, we are adopting digital changes, such as online shopping and app based food delivery, into our day-to-day routines. However, when it comes to digitising the food industry, some might ask, 'How can we digitalise food production? Where would we start? It's too complicated!'

If we take a closer look at this versatile sector, the enormous potential in applying the technologies provided by digitisation become increasingly apparent. Despite this, when it comes to the digital journey, the food industry is way behind other manufacturing sectors, such as automotive or pharmaceutical, who have already embraced digital change.

Food companies face several challenges in introducing innovative solutions, including human resource limitations, financial risk and lack of information about technical feasibility.

Adopting new technologies can result in an extended return on investment, but also hidden costs caused by process disruption and decreased performance. In addition, the sector is highly diverse; every food processor has its own technological processes and methods, using several different raw materials with varying characteristics and quality. Therefore, standardised solutions are not applicable in most cases – companies need the technologies to be tailor-made for their specific needs and requirements.

Recent unexpected events, including the pandemic and geopolitical and global economic changes, have made the situation for the bakery industry even harder.

Currently, the price of raw materials and energy are not stable or easily calculable. Together, these issues culminate in making the financial aspect of bakeries complicated, but the adoption of digital technologies could support them to increase competitiveness.

"The food industry is way behind other manufacturing sectors, such as automotive or pharmaceutical, who have already embraced digital change."

The position of the baking industry in the digital transformation landscape
The role of the bakery industry is far more than merely serving consumers with delicious and nutritious products. In Europe it has significant economic importance as the employer of approximately 1.5 million people, equal to a 34% share of the food and drink industry's employment; additionally, in the food and drink industry more than 99% of the companies are small and medium-sized enterprises, with the bakery and farinaceous products sector accounting for 52% of those companies (FoodDrinkEurope: Data and Trends 2021). However, at branch level, technological development in these small businesses is usually low: processing steps are not usually optimised and production is planned solely on the personal experience of staff at most bakeries.

In the bakery industry, companies normally have a broad product assortment while having a low margin on the selling price. Stale bakery products cannot be sold, resulting in a high amount of wasted food products, equal to the waste of all the raw materials, energy and human labour used for the production.

The goal of PrO4Bake is to tackle these challenges by minimising food waste, reducing energy consumption and improving bakery practice by increasing efficiency and decreasing costs, without disrupting routine processes.

PrO4Bake – Enabling bakeries to achieve more with less investment
PrO4Bake is a computational tool that enables bakeries to decrease food waste, energy consumption and costs. The tool's novelty lies in using the optimal scheduling of the production plan in combination with a daily prediction of consumer demand through advanced machine learning methods.

Bakeries generally offer a wide range of products, differing in shape, size and flavour, prepared with different technological parameters (temperature, humidity) and inconsistent processing step durations. The products and their preparation steps need to be put in an optimal sequence to achieve optimal production, with the best utilisation of machine capacities and efficient energy use. The sector is relatively energy-intensive and the utilisation of high energy consuming equipment, such as ovens, dramatically influences business production costs.

All of these influencing factors are considered in the analysis of production processes and the PrO4Bake tool generates the most efficient production schedules based on the data. For this purpose, it applies digital twins of the production using a flow-shop model and models for equipment, like ovens. These digital twins and demand forecasts created by artificial intelligence procedures are used for an optimisation of schedules by evolutionary algorithms.

Implementation enables the efficient

use of already available resources in bakeries without additional costly investment and production hold-ups due to time-consuming installation.

According to estimates, bakeries applying the tool can achieve a 7%* reduction in the total lead time of the production programme, resulting in additional benefits, like the reduction of energy consumption by 10%*, a decrease in labour costs, carbon footprint and maintenance costs. Tool adoption enables a significant estimated increase of 20%* in production capacity, without any additional costly investment. Moreover, a thorough analysis of the processes enables identification of potential bottlenecks in production.

"Issues culminate in making the financial aspect of bakeries complicated, but the adoption of digital technologies could support them to increase competitiveness."

The demand forecasting tool helps with assortment planning by providing accurate predictions of the number of products to be sold by type and volume. For this purpose, the algorithms are trained using historical sales data from the bakery and other relevant data from external sources, like weather and holidays, which may influence daily demand. Finally, the prediction is refined by applying current sales data.

The decrease in unsold products reduces food waste by 5%*, contributing to an approximate 5%

reduction in materials, energy, labour and maintenance costs.

Societal benefits include the reduction of the bakery sector's carbon footprint and introducing the PrO4Bake approach will also enhance the digital culture in food processing.

PrO4Bake project development

The PrO4Bake project started in January 2020, initially as a two-year project supported by EIT Food and was extended to the end of April 2022 due to the pandemic. The project's goal was to support European bakery businesses by developing a solution to optimise processes in the baking industry. To this end, experts from different areas worked in close collaboration during the project period to gather the skills and knowledge needed.

This included areas like the application of artificial intelligence and simulation using digital twin software development, advanced optimisation algorithms, food quality and safety, baking technology and consumer sciences.

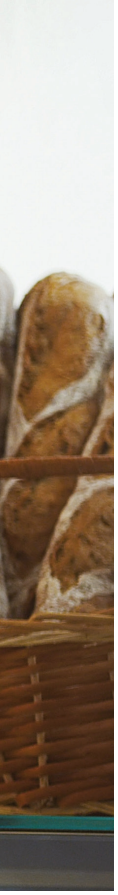
Members of the project consortium led by the University of Hohenheim include Siemens, the Universities of Aarhus, Lund and Turin, the Institute of Animal Reproduction and Food Research of the Polish Academy of Sciences, the Spanish National Research Council CSIC and Campden BRI Hungary.

Consumers from seven countries (Denmark, Germany, Hungary, Italy, Poland, Spain and Sweden) were involved in the development process via co-creation. Experts studied customers' preferences and shopping habits to get a deeper understanding of bakery product consumption. As a result, EIT Food nominated the PrO4Bake project for the EIT Innovators Award and at an event held in December 2020, the project was represented by András Sebők, retired general manager of Campden BRI Hungary.

In the course of developing the computational tool, partners worked together with several bakeries from the seven countries. In the first phase, the partners collected production and sales data. The focus was on the everyday realities of bakeries, trying to make the approach useable for both bigger and smaller enterprises.

Several modifications were made during the data collection period based on experiences at the bakeries involved. Partners used an excel template to list all relevant information about the production in a structured way to collect the production data. There were many challenges to overcome, such as how to handle the preparation steps needed for human labour or how to describe production processes having sections with both batch and continuous production. Through ongoing communication with the bakeries and their help and assistance, these issues were resolved.

With sales data, the level of digitisation was a key factor; in some cases, at small artisanal bakeries, sales data was only available in paper format and not in any digital form. In these cases, the use of the demand forecasting tool was only sustainable if the company was able to change this routine and start to keep track of sales digitally. However, in most cases, the minimum six months sales data or more was available, enabling training around the module's algorithms. For the import, only minor changes were needed in most cases.



The huge amount of amassed data was used to build a solution that fits the expectations and includes all the functions a real-life bakery business needs.

The first test of the developed tool took place in the well-equipped pilot bakery at Campden BRI in Chipping Campden, Gloucestershire, UK. The infrastructure allowed the execution of a previous production plan in a controlled environment and the measurement of the ovens' energy consumption. Using the measurement data, experts at Siemens built a model of the energy demand, achieving sufficient accuracy.

In the final phase of the project, feedback workshops took place in several countries to harness the opinions and ideas of the bakeries involved and ensure the feasibility of the tool's application. The overall impression of the participants was positive, and they were satisfied with the functions, structure and outline of the two modules. Participants were surprised by how detailed information can be uploaded to the production scheduling module and how many factors can be included to get the best optimisation results. They gave positive feedback on the opportunity to plan the need for human labour and competence in production. In the workshops, the participants gave valuable feedback and shared inspiring ideas for making the tool more user-friendly and useful. Consumer research underpinning the importance of avoiding food waste from bakeries (e.g. unsold products or overproduction) was conducted by the University of Aarhus and was fed back to bakeries. Overall feed-back stressed again the importance of accurate production planning in mitigating bakery waste and saving energy.

How PrO4Bake is used by bakeries. Outcomes to carry forwards.
Using the tool is relatively simple via a web app. It is easily accessible for customers using their own login data and available anywhere through any internet browser, making it convenient and flexible.

Once all the required data has been uploaded, users can generate an optimised production schedule. The scheduling can be displayed by batches, products, machines or even by person and the details of the specific steps (for example, the machine used or the number of employees required), are also shown. Based on the data entered, the tool calculates important key performance indicators (KPIs) for production, like makespan and idle time and estimates the energy consumption.

An upload of recent sales data is needed to generate the sales demand forecast. After that, products of interest can be selected and the forecast for the required period can be generated.

Detailed information on the optimised schedule and demand forecast can be exported for further use or reporting purposes.

Although routine use of the application was designed to be user-friendly enough for anyone who has basic digital skills, bakeries need assistance during the introductory phase of the tool. Adoption requires a thorough analysis of production combined with understanding and reliable knowledge regarding food industry operations and the concept of the computational tool. The bakeries involved highlighted that assistance is essential for defining, gathering, cleaning and handling related data. To this end, Campden BRI Hungary offers training and consultancy services to assist with the implementation and application of the tool and to support bakery businesses with the digital transition.

The most important conclusion from the project was that collaboration with real-life bakeries is key to gaining an insight into the challenges and needs of the sector, as well as obtaining the necessary information to develop a suitable, tailor-made approach for the baking industry.

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*According to the estimations by the University of Hohenheim.

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DURRER:
increasing efficiency, saving energy

A vacuum cooler is a wonderful thing. By cooling down oven-hot baked goods in an instant, vacuum cooling increases efficiency and productivity in the bakery. Rolls and pastries become even airier, crispier and have a longer shelf life. Durrer's new vacuum cooling system stands for genuine Swiss quality and first-class service throughout the entire operating time and at a truly unbeatable price-performance ratio.

Written by:

Bruno Stierli **René Hunziker**

Durrer Spezialmaschinen AG

Durrer Spezialmaschinen AG is a Swiss family business. A spirit of innovation and technical sophistication has been part of the company's DNA for over 70 years. Durrer develops solutions for the medical and sensor technology industry, with vacuum technology being one of our specialities – as used in the baking industry.

They have been successfully developing and producing vacuum coolers for twelve years.

High-tech saves energy
Durrer Spezialmaschinen AG is now using its experience and extensive network to launch a new generation of vacuum cooling systems. What immediately catches the eye: the great design and the Durrer logo emblazoned on the device, but what really matters is what's inside: the latest technology, the ultra-modern and most efficient pump systems in Durrer's uncompromising quality products. The systems are Industry 4.0-ready, which means they can easily be integrated into existing systems – and all this at an attractive price.

Everything from one source
An important aspect that guarantees for a consistently high quality standard: at Durrer, all development and production steps take place in-house – with quality control completely in our own hands.

As we have extensive know-how, this also applies to the maintenance and repair service over the system's entire service life.

A sustainable investment
"For us, the installation of a vacuum cooler is only the beginning of our partnership. We are there for our customers at all times and strive for systems that operate uninterrupted for years, even decades", CEO Ludwig Durrer says. The decisive factor is that Durrer systems are serviced worldwide by experts who know the technology and how it works in detail. Investing in a Durrer plant not only increases productivity in the short term through enormous energy savings, but it is also a worthwhile investment that pays off in the long run.

Greater efficiency, better bread rolls
Durrer vacuum coolers are powerful and extremely reliable – well, they are "Made in Switzerland". The system offers significantly more efficiency in the bakery. Within a few minutes, oven-hot bread, rolls and pastries are cooled down and become crispier, airier, simply better – and they stay fresh longer. "The feedback we receive is consistently enthusiastic because our customers are delighted with the baked goods," Ludwig Durrer confirms.

> "At Durrer, it is always about finding an optimal solution together and with an open, honest dialogue."
>
> **Peter Storfer**, Knusperstube Bäckerei GmbH, St. Gertraud, Austria

Adaptable to individual needs
Durrer vacuum coolers are available as standard or customised versions –

at no extra cost. Durrer uses the latest pump technology from the world market leader and long-standing partner, Busch. The pump capacity is matched to the respective product, so every Durrer vacuum cooling system is tailored to individual requirements and the circumstances in the bakery. "Our vacuum coolers not only save time and space, but also energy thanks to the possible oven time reduction of up to 30%," Ludwig Durrer says.

Proven in practice

Swiss industrial design is obviously more than just pretty in appearance. Performance, reliability, and long-term benefits are undeniably convincing qualities. A Durrer vacuum cooler is a worthwhile investment all round, as bakeries that already use it confirm: "Durrer knows what they are talking about. The expert advice is excellent. In addition, they have extensive experience in vacuum technology," Gerald Geier from "Geier. Die Bäckerei GmbH" in Strasshof near Vienna says. In short: Durrer is the ideal partner for every bakery.

"At Durrer, it is always about finding an optimal solution together and with an open, honest dialogue." Peter Storfer, "Knusperstube Bäckerei GmbH", St. Gertraud, Austria.

FOR MORE INFORMATION

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Durrer Spezialmaschinen AG – from Central Switzerland to the whole world

The family business has its headquarters in Immensee. In addition to its original specialty of manufacturing machines for the graphics industry, the focus is on highly developed vacuum technology, for the bakery and medical technology industries among others. An innovative spirit and interest in new technological developments are part of the company's DNA. Today, Durrer machines contribute to efficient and optimised production processes worldwide.

CIRCULAR ECONOMY

in the Baking Industry

What are the challenges the industry faces to become more circular?

Written by:




Jonata Massao Ueda **Márcio Carocho** **Sandrina Heleno** **Lillian Barros**

Researchers from the Centro de Investigação de Montanha (Mountain Research Centre) at the Polytechnic Institute of Bragança in Portugal

Due to the environmental impact associated with food waste, the management of raw materials is essential for sustainable development, where the transformation of "waste" into a "resource" is the main goal[1]. To reduce food waste, the aim of circular economy is to reuse these resources that would otherwise be discarded, ensuring a competitive economy and generating new jobs[2,3].

In 2015, the first action plan for a circular economy in Europe was adopted, aiming at transitioning European countries and ensuring greater global competitiveness[3].This went further in March 2020 when the European Commission defined a new plan for a circular economy, focusing on the design of sustainable products and "circular jobs", which would ensure lower waste levels[4]. Lastly, regarding the historical backdrop to this new plan: since 2020 many proposals relating to waste shipment, pollution in industrial facilities and packaging waste have been adopted throughout the union[5].

Bakery products are considered, along with cereals, as one of the biggest sources of waste among food groups, in which bread represents up to 20% of bio-waste in bakeries and is often discarded due to deformation of shape or undesirable visual marks due to over-baking[6,7].

In general, bakery goods have a brief shelf life when stored at room temperature, making them unsuitable for consumption after a relatively short period of time, due to either undesirable characteristics or contamination with bacteria and moulds [8]. To reduce this loss, some solutions are being researched, namely the use of food preservatives to increase shelf life, the application of edible films, or even the use of active packaging[8].

To satisfactorily implement circular economy, a thorough redesign of the baking industry is also essential, specifically in production processes as well as in the packaging of the product itself. This redesign, beyond improving the circularity of the production process also helps the consumer to understand how to make more sustainable purchases and use fewer resources[2].

Packaging is one of the main areas where the industry needs to overcome challenges to become more circular, especially given that plastic and paper are the most commonly used materials. Although some plastics are recyclable, namely thermoplastics, they have a limited life cycle in terms of recyclability, as does paper[9].

The development of an ideal packaging for bakery products is a challenge, as it must have specific properties, namely preventing the bread from losing moisture too quickly, avoiding an environment with high humidity, limiting the proliferation of microbial contaminants and finally, ensuring protection against oxidative reactions and consequently changes in sensory properties[10]. One potential solution would be to use "re-closable" packaging allowing a longer shelf life for baked goods by avoiding contact with other sources of contamination[11]. However, this technology is far from ideal. The main issue with re-closable or re-usable packaging is related to its cost of production relative to its effective use. This cost is usually higher than for single use packaging and while consumers are open to spending a little more for sustainable packaging, there is still a point at which they will consider a sustainable product too expensive. Obviously, the key here is to have the price of the item below this threshold, although this hypothetical amount does vary from country to country and even within the country itself. Other issues related to this challenge are the extra transportation logistics (in the case of returnable packaging) or the inconvenience for consumers themselves to bring the packaging back to the point of return. In some countries there are incentives for this returnable packaging, but implementation has not been widely adopted.

The production of microbial biodegradable polymers from agro-food waste residues is one of the most promising ideas for food packaging, including bakery goods. Here, two sustainable concepts are combined in a solution to reduce plastic packaging, namely the use of residues and production through

"Academia has now reached a point where there are sustainable alternatives to most plastics."

bio-fermentation. Another important measure is the change in packaging properties, either by incorporating antimicrobial compounds in the packaging system obtained from fruit or vegetable by-products with bioactive potential, or by using modified atmosphere packaging (MAP) to increase the shelf life of these foods[12]. The baking industry uses many types of plastics, and thus can benefit from the innovation brought about by science. Luckily, the industry does not need tailored solutions, which is to its advantage. Still, comparatively, the "circular" alternatives are sometimes 20% more expensive and there are trade-offs in performance, which have hindered their widespread implementation in several industries and specifically the baking industry. Legislation in itself hardly makes a difference, mainly due to the most radical aspects being imposed on the plastic producers rather than the retailers or consumers.

"Science has helped remove many of the barriers to circular economy."

Thus, one way to extend the use of biodegradable polymers and other circular packaging is for governments to fund the use of these sustainable alternatives, reducing the investment both from industries and consumers. Academia has now reached a point where there are sustainable alternatives to most plastics and it is now focusing on reducing the trade-offs and drawbacks of these products to make them more viable and to keep them for longer in the circular economy.

Focusing on ingredients as food waste, wheat flour, which is the most used ingredient in bakery products, is responsible for the highest caloric intake of the world population, as it represents approximately 1/3 of all grain crop production. Practicing circular economy for this type of product in the food chain is essential for sustainable development. Reducing organic waste can be achieved by several means, namely by adding them to previous steps of the value chain, by composting leftovers, using them as feed for other industries or even using them for the packaging of the product[13]. This is the final concept of circular economy, in which there are no leftovers, no residue that goes to waste and where all products are used in some step of a circular flow of these products.

Some small steps have been made on this front, namely in the application of other food matrices in flours, several by-products from fruits and vegetables, such as peels, seeds, stems, leaves and pomace have already been studied as a source of functional ingredients for incorporation into flours for breads and cakes, generating benefits such as increased shelf life, improved nutrition and bioactivity (antioxidant and antimicrobial properties)[15].

Science has helped remove many of the barriers to circular economy, namely by: creating techniques to recycle and upscale leftovers; transferring residues to packaging and connecting different industries to allow a flow of residue from one to another. Circular economy can also go beyond the product itself. It can also be considered from an energy standpoint, namely by the use of heat from baking being used to produce energy to power other parts of the production line. Circular economy is the drive to lose the least while gaining the most.

It is also up to consumers and producers to implement simple but highly effective actions to reduce waste, e.g., by selling baked goods from the previous day at reduced prices, selling unpacked breads, using crumbs and leftovers as flour for less premium baking or by using leftovers for other industries such as the beer industry.

Still, the two major drawbacks that have delayed the spread of circular economy in the baking industry are convenience and economy. While the drawback for the latter is easily understandable, great investment is needed to reduce waste, as even the less costly measures are rarely taken – convenience plays a critical role: is it convenient for consumers to buy an

unpacked baked product or a pre-stale bread or to keep crumbs and make flour out of them?

To some consumers, who are focused on sustainability when considering their purchases, this idea might be convenient, but many others would not make the same choice. So, this compromise between sustainability, economy and convenience is the triangle that science and industry must contend with to deliver the most sustainable baked goods and for a price that the consumer is willing to pay. No consumer would buy an overly expensive unpacked pre-stale bread, even if it were produced with leftover crumbs, had a zero net carbon dioxide impact, was enriched with functional ingredients and baked using locally produced timber and using energy from wind turbines.

The most recent European legislation regarding food packaging and food contact materials dates from September 2020, amending the regulation of 10/2011. In the document, there is no reference to circularity in the economy or sustainability. Still, in the 2018 amendment of the directive 94/62 on packaging and plastic waste, there are specific goals that member states should reach, namely 65% of all packaging waste should be recycled by 2025, although the figure is only 50% for plastic packaging. By 2030, 70% of all packaging should be recycled, although this only climbs to 55% in relation to plastic. These goals seem quite unambitious, especially given the expected increase in plastic output by developing countries, rendering the net waste higher than the present day. These goals will only become more ambitious if consumers demand it and if the industry can cope. The Ellen MacArthur foundation has carried out much work on taking the concepts of circularity to the main participants in plastic production and consumption. Beyond this, the foundation has helped set up several European Plastic Pacts (between France, Ireland, Spain, Portugal, United Kingdom, Denmark, Norway, Belgium, Netherlands, Finland,

About the authors
The authors are researchers from the Centro de Investigação de Montanha (Mountain Research Centre) at the Polytechnic Institute of Bragança in Portugal. They have focused most of their research on food science, including bakery products. Together they have published over 400 research articles, patents and book chapters, while also promoting technologies to various industries in the food sector.

Sweden, Germany, Switzerland, Greece, Austria, Lithuania, Latvia, Hungary, Slovenia, and Italy) which include companies (plastic producers, consumers, recyclers), research centres, universities, NGOs, governments and public sector organizations, to help guide the way on a more circular economy, specifically on plastics.

In the future, it is hard to guess how much circular packaging will be part of the food industry, it always depends on the international agenda. By 2025, the European Plastics Pack aims at having all plastic packaging designed to be reused, reducing 20% of virgin plastic in packaging and having companies use at least 30% of recycled plastics.

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DEVELOPING A FUTURE

for the baking industry

Written by:

Lee JM Pugh

Head of Baking
ZERO2FIVE Food Industry Centre / Canolfan Diwydiant Bwyd ZERO2FIVE

Challenges facing the baking industry

The challenges currently facing the baking industry are numerous. From a lack of staff and more highly qualified staff and bakers, to rising raw material costs of ingredients and packaging, not to mention ever increasing energy and fuel costs, there are no easy fixes for any of these issues and they will continue to put pressure on businesses for the foreseeable future.

The industry and national bodies need to work together as much as possible, to promote careers in the bakery industry. In addition, staff training is now more important than ever to retain skills within the industry and develop the experts of the future, who can pass on their knowledge to new career starters. Here at Cardiff Met University, we try to encourage our students into the bakery sector, as bakery is only part of their Food Science degree.

The lack of young talent in the food industry is reflected in the numbers enrolled at the university. Whilst we have around 60 Food Science students across three year groups, there are over 1000 Sports Science students. This clearly puts into context the challenges facing the food industry in attracting new employees and bakery is just one part of the overall picture.

Industries all over the country are finding it harder than ever to recruit staff and the bakery industry is no different. Finding qualified bakers and retaining them, is becoming increasingly difficult, as general competition in the work place grows. At ZERO2FIVE we are being asked

> "Finding qualified bakers and retaining them, is becoming increasingly difficult, as general competition in the work place grows."

"Bridging the gap between students and industry and promoting careers in the bakery sector is a major factor in helping bakeries of all sizes."

more and more often to help train apprentices, as bakeries look to develop their own young bakers.

Collaborating with industry to nurture future bakers

One way we hope to make careers in the baker sector more appealing to our students is by working closely with ingredient suppliers to allow them to gain experience with the latest developments in the industry. One example is our collaboration with Puratos, who regularly send ingredients to a selection of our students for them to use in developing new recipe ideas. This is something we hope to build on, as well as engaging with global companies more often in the future.

Bridging the gap between students and industry and promoting careers in the bakery sector is a major factor in helping bakeries of all sizes. This autumn we hope to organise a presentation day with speakers to include a major ingredient supplier, an industry business, an equipment supplier, trade associations and a wholesaler. Tailored towards an audience of bakery customers as well as our students, we hope this event will provide an opportunity for a cross-section of the industry to come together in one place: challenges can be explored, new ideas can be presented and career hopefuls can meet professionals, to gain valuable insight into their chosen field.

As part of their degree, our students participate in 12-month industrial placements and we are looking to further develop the bakery aspect of

this programme. Many of our students want careers within the baking industry and we try to organise placements for them within bakeries where they can learn and be exposed to the many paths that may lead to a possible career, whether this be on the

About ZERO2FIVE Food Industry Centre

ZERO2FIVE Food Industry Centre at Cardiff Metropolitan University brings together a unique collaboration between industry-experienced technical, commercial and operations managers and respected academics.

Our position within Cardiff Metropolitan University's School of Sport and Health Sciences enables us to draw on academic expertise from a broad range of food related subjects including food safety behaviour, food science and technology, psychology, nutrition and microbiology.

With the support of the Welsh Government, we work with around 150 Welsh food and drink companies every year. We engage with companies and organisations of all sizes and stages of growth to provide support with factory design, start-up advice, new product development, third party certification and global food standards compliance (including BRCGS and SALSA), food safety and security, food and labelling legislation, nutrition, market analysis and marketing.

Our state-of-the-art facilities are available for use by food and drink companies and include food processing and development units for low and high-risk foods, bakery and confectionery; development kitchens; Wales's largest sensory evaluation suite; and a state-of-the-art Perceptual Experience Lab (PEL) for simulating retail and factory environments.

Food Innovation Wales and Project HELIX

ZERO2FIVE works closely with the two other food centres in Wales (Food Technology Centre in Anglesey and Food Centre Wales in Ceredigion) and together we form Food Innovation Wales, an organisation which delivers pan-Wales industry support through the Welsh Government and EU-backed Project HELIX.

With its triple helix approach, Project HELIX brings together government, academia and industry to work together towards mutually beneficial outputs that contribute to the Welsh Government's strategic objectives for the sector. Through Project HELIX, eligible Welsh food and drink companies have access to a range of short, medium and longer term technical and commercial support.

Since it launched in 2016, Project HELIX has delivered an impact of over £185 million to the Welsh food and drink industry. Playing a key economic role in Wales's local communities, Project HELIX has supported the creation of 447 new jobs and safeguarded a further 2306. Having worked with 382 businesses across Wales, the project has helped with the development of 1240 new products and provided access to 778 new markets.

The baking industry and SMEs and start-up companies

At ZERO2FIVE we regularly provide help with advice and testing facilities for start-ups and growing companies in the baking industry. This can relate to any aspect of their business from waste management, recipe development and equipment advice to bakery layout, packaging, distribution, premises, and marketing.

Through the HELIX Knowledge Transfer Programme we also embed part-funded technical or sales and marketing affiliates into Welsh food and drink manufacturers. This enables companies to have access to graduate level members of staff with the full support from the experienced team at ZERO2FIVE, who coach and mentor the affiliates.

Businesses can also gain access to our sensory evaluation suite to independently evaluate their products and our Perceptual Experience Lab (PEL) where we can help them to consumer test their packaging designs in a close to real life environment.

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technical side, product development or production.

Technological solutions for the baking industry

Rising costs are a challenge for everyone and we believe bakery prices will have to increase for businesses to maintain their profits and therefore have capital to re-invest. However, we also recognise this must be balanced against reduced sales and the streamlining of production lines.

Against this challenging backdrop we aim to support the baking industry by finding new ingredient suppliers and raw material sources for Welsh businesses. As part of this process, we are working with other universities across the globe, in countries such as the USA and India.

Another area of focus is bakery equipment. Manufacturers are currently developing machinery that is more economical to run e.g., wood pellet fired ovens or fan-assisted deck ovens with shorter baking profiles. Equipment that can produce close to artisan products, but which requires just one or two operatives to run efficiently will greatly benefit the industry in the future.

More than ever, we think that the bakery equipment industry has a big opportunity to develop systems and equipment to reduce the number of staff required. It will be very interesting to see in the next few years what new technological advances come to the market.

We believe challenges for the baking industry will continue for some time to come, but bakers across the globe face similar problems and we have seen this first-hand, having worked in many different countries. However, these challenges also present opportunities. As an industry we should focus on developing a way forward and working with government to create a national bakery apprenticeship, something which we do not presently have in Wales. The baking industry also needs to better promote itself to younger people, whether through school engagement initiatives or programmes to encourage young people to embark on a new career in the bakery industry.

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ORIENTATION BIASES IN FOOD PRESENTATIO

(& what you need to know about them)

Written by:

Professor Charles Spence

Crossmodal Research Laboratory, University of Oxford

Take a look at the two delicious-looking crème-filled chocolate éclairs shown above. Given the choice, which one would you prefer, assuming, that is, you can't have them both? It may surprise you to learn that according to the latest research from Japan,[a] more than a third more people preferred the bakery product shown on the left (i.e., the one that is oriented from bottom-left to top-right) over the same éclair when shown oriented from top-left to bottom-right instead (as shown on the right). The éclairs are identical and yet research demonstrates how much the way in which they are presented influences consumers' preference. In particular, 67% of the time, when young right-handed Japanese consumers were shown pairs of foods, such as these éclairs and also other foods that could also easily be grasped with one hand, e.g. a sandwich, or a slice of pizza, they preferred the food that was shown oriented from bottom-left to top-right: the mirror image was only preferred in 33% of cases (i.e., with the food oriented top-left to bottom-right). Intriguingly, the researchers found no such preference for pairs of pictures that included a linear element such as a bridge (again going from bottom left to top-right, or vice versa). That said, others have shown a preference for those works of art that can be 'read' from bottom-left to top-right.[b]

If baked goods manufacturers could increase their customers' preference for their products by simply changing the orientation in which they display them in-store, or in an advertisement, wouldn't they want to know how? Some people might question whether such orientation or directionality biases are culturally-determined. After all, the Japanese participants who took part in the aforementioned study read in a different direction (from top to bottom, and right to left) from those of us in the West. How might this influence their aesthetic preferences, when compared to

those of western consumers who read differently? The answer, or so it would seem, is not much.[c] In fact, similar directionality and/or turning biases have now been shown, across many different nationalities.[d]

In research conducted at the Crossmodal Research Laboratory here in Oxford in collaboration with chef Jozef Youssef of Kitchen Theory fame, we have been able to show exactly the same ascending-to-the-right bias when presenting plates of food to diners in the UK.[e] In our research, we spun a picture of the dish of Smoked cox apple crème, cobb nuts, homemade curd, apple caviar & beetroot reduction (shown Fig. 1) on people's computer screens. We had them pick their preferred orientation for how they would have liked the dish to be served were they to go to the restaurant.

Each person's preferred orientation for the dish is indicated by one of the black dots arranged around the plate in this circular data plot and purple rose diagram. The results clearly show how the majority preference amongst the hundred participants tested was for the ascending-to-the-right orientation of the dish. No surprise to learn, therefore, that this was the precise orientation that this dish was subsequently served to diners in chef Jozef's gastrophysics dinners. We have subsequently been able to demonstrate exactly the same preference for the ascending-to-the-right (over ascending-to-the-left) presentation in the plating of a range of different dishes of food–what some have been minded to call 'food porn' or 'gastroporn'.[f] At the same time, however, it is clear that many chefs have already intuitively picked-up on this bias in food aesthetics in the dishes that they display on social media, etc.[g]

According to the research, people's orientation preferences when it comes to the presentation of food may have something to do with how graspable they (the éclairs in this case) appear to be in the different orientations. Cognitive neuroscientists have shown that our brain automatically generates a motor program as it simulates the act of grasping any objects that it sees.[h] Furthermore, the easier it is to imagine, or simulate grasping the food, the more we like what we see – as our brains can process it more fluently. Of course, this is influenced by whether the consumer happens to be left- or right-handed. But even a cup or mug is preferred when its handle happens to be oriented toward the viewer's dominant hand (rather than toward their non-dominant hand instead).[i]

While most of us may well choose to eat a chocolate éclair with our hands, there are undoubtedly many other foods that are more conventionally consumed with the aid of cutlery – think soup or shepherd's pie. In such

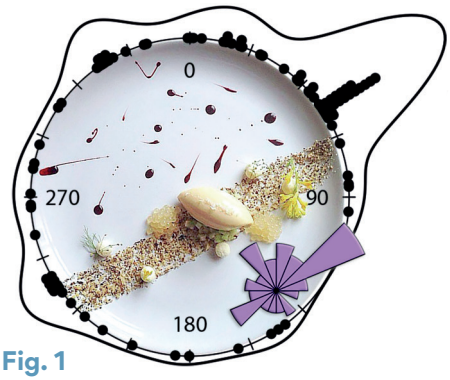

Fig. 1

cases, simply showing the soup spoon positioned on the right of a bowl of soup in an advertisement (assuming that the majority of people are right-handed) can give rise to a slight, but nevertheless still significant preference, which importantly, translates into increased purchase intent, due to the facilitation of what the scientists working in the area term 'embodied mental simulation'.

Of course, it is important to note that the orientation in which you display your bakery products isn't the whole story as far as optimising the aesthetic presentation is concerned. The research published over recent years also demonstrates that people prefer a balanced presentation of the food on the plate, or in a food display, over a presentation that appears unbalanced instead.[j] This is obviously something that those behind the insanely popular Symmetry Breakfast enterprise would appear to have cottoned-on to. At the same time, however, one might wonder about the recent trend toward the asymmetrical plating and presentation of food that one comes across in many modernist, fine-dining restaurants. In the latter case, research from my colleague Jeremy Roqué has shown that people tend to assume that asymmetrically-presenting one's food means that whoever is behind it must be more creative;[k] It is simply that creative

"It is clear that many chefs have already intuitively picked-up on this bias in food aesthetics in the dishes that they display on social media."

plating is not necessarily something that diners are necessarily willing to pay more for![l]

One final suggestion as far as optimising the eye-appeal of your bakery presentation is concerned is to make sure not to point any angular foods, such as a slice of cake, toward the customer. Silly though it may sound, our brain's fear circuits tend to be activated whenever we catch sight of something angular pointing towards us, even if it is something as seemingly innocuous as a slice of pizza or cake.

The suggestion from the evolutionary psychologists in this case is that the primitive brain considers something angular pointing toward us as a possible weapon that could be dangerous. In our online research, we find that the angle at which triangular foods such as a slice of pizza or chocolate cake are shown, subtly influences consumer preference.[m] In particular, downward-pointing food is rated as significantly less pleasant, less liked, and less familiar than when the same food points upward instead.

So, given the choice, my advice would be to make sure that the cake slices that you display, or serve, to your customers do not point

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About the author

Professor Charles Spence is a world-famous experimental psychologist with a specialization in neuroscience-inspired multisensory design. He has worked with many of the world's largest food and drink companies across the globe since establishing the Crossmodal Research Laboratory (CRL) at Oxford University in 1997. Prof. Spence has published more than 1,000 academic articles and edited or authored, 15 books including the Prose prize-winning "The perfect meal" (2014, with Betina Piqueras-Fiszman), and the international bestseller "Gastrophysics: The new science of eating" (2017; Penguin Viking) – winner of the 2019 Le Grand Prix de la Culture Gastronomique from Académie Internationale de la Gastronomie. His latest book, Sensehacking, was published in January 2021.

> "An emerging science around the aesthetic presentation of food that provides a number of clear and more importantly, actionable recommendations for those working in the bakery industry."

downward or directly toward them. In fact, given what has been noted above, the best orientation to increase the appeal of your products is most likely going to be ascending to the right! So, while we may never give it much thought, there is, in fact, an emerging science around the aesthetic presentation of food that provides a number of clear and more importantly, actionable recommendations for those working in the bakery industry.

The bottom line here is that a growing body of gastrophysics research now clearly demonstrates that optimising the visual presentation of your bakery products can exert a significant uplift in the appeal and willingness to purchase, of whatever it is that companies happen to be selling.

FOR MORE INFORMATION →

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