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SPRING 2022

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Why we are turning the temperature down to save waste

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Insects are the future; we find out how and why

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We find out how snacking correctly is better for the consumer and the planet

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PRINTING
Baking Europe is printed on FSC/PEFC certified paper in the UK by The Magazine Printing Company

FSC www.fsc.org MIX Paper from responsible sources FSC® C013417

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WELCOME

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

When I think of the Spring Edition of *Baking Europe* it puts me in mind of lighter, sunnier days, when a host of seasonal ingredients start to grow. However, at a time when we start to think about an abundance of things to eat, there have been shortages.

Repercussions from the conflict and tragedy in Ukraine have been felt on a global scale. At a time when we are reminded that we should not take anything for granted, our article, Counting the Cost of Bread, on page 62, looks timely. This article considers the cost of wasting bread and gives simple and insightful ways for consumers and businesses to reduce waste.

From our longstanding relationship with the loaf to a potentially new one: insects! There are pros and cons with most ingredients, but insects do tick a lot of boxes when it comes to nutrition and sustainability. On page 8 we look at the benefits of using insects as a baking ingredient and BE regular, Dr Charles Spence, considers whether we can change our eating habits to make bugs the next buzz in baking, on page 66.

In other news, it has been good to see bakery exhibitions back, a sign that the sector is getting back to business after the restrictions of the pandemic. Whether you're busy, back at the office or at working from home, when in a rush you're more likely to snack rather than stop for a meal. We all want to eat healthily, even on the go, so find out how natural flavourings can be tasty on page 24 and on page 44, how eye tracking technology is being used to help understand how we choose our favourite snack, biscuits!

Finally, if you're considering a spring clean of your baking machinery, see page 48 for a cutting edge look at how plasma could change our traditional approaches to hygiene and a very cool article on page 36 explains how bakery goods could benefit from superchilling.

Speaking of superchilling, hopefully spring brings with it some much needed warmth and the bakery industry, amongst others, can come in from the cold.

Richard Henderson
Sub Editor

THE USE OF INSECTS

Written by:

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Flavia Casciano[2*]

Andrea Gianotti[3*§]

The use of insects in foods is a viable strategy that could pave the way for a more sustainable food industry in the future. In fact, the Food and Agricultural Organisation (FAO) has estimated that by 2050 the demand for food will be difficult to satisfy, since by then, the world population may well exceed nine billion.

Presently, 40% of the earth's land is used for food production, however, the availability of sufficient arable and grazing pasture is rapidly declining. Tackling this urgent challenge is leading to the discovery not only of new ways of farming efficiently, but also new food sources that can be produced sustainably without the need for as much land.

In developing countries for example, it is necessary to provide protein rich foods, particularly those rich in vitamins and microelements, to help form a balanced diet for both children and young people. In the western world, on the other hand, there is a growing demand for high quality proteins to be used as a supplement for athletes, in special diets for the elderly, for people with specific conditions, such as coeliac disease, as well as for vegans and vegetarians. As has been covered many times in *Baking Europe* over the years, readers will be aware that coeliac disease is a chronic, systemic, autoimmune condition caused by a lifelong intolerance to gluten proteins in genetically susceptible individuals. Currently, the only therapeutic pathway for coeliac disease sufferers, regardless of the severity of the symptoms, involves the adoption of a gluten-free diet. The importance for manufacturers to provide gluten-free foods for this group is self-evident and includes products that have better taste, improved organoleptic and nutritional qualities. In fact, it has been argued that currently available gluten-free products are often inadequate due to their low protein content and high fat and salt content.

Given the known difficulties in baking with gluten-free doughs, it is particularly important to study the feasibility of integrating gluten-free foods with added proteins, a process that will increase a product's intrinsic value through its enhanced properties of the dough, such as displaying better viscosity, elasticity, cohesion and importantly, volume.

Protein supplements and concentrates are mainly produced from vegetable or animal sources, however, the production is unsustainable due to the relatively large CO_2 footprint of animal farming. The continuing depletion of the Amazon rainforest further negates the benefits of arable farming for protein rich vegetables, such as soya beans, resulting in a veritable "chess-like" stalemate for the baker.

The next move – insects?

Unlike this virtual game of gluten-free "chess", there is a third route available which involves the inclusion of insects

> "It has been argued that currently available gluten-free products are often inadequate due to their low protein content and high fat and salt content."

S IN BAKING

as an ingredient in recipes for protein enrichment. It has been proven that proteins from certain arthropods represent a practical, cost-effective alternative to meat and poultry derived proteins. One specific species, house crickets (*Acheta domesticus* L.), contain approximately 69% protein content and are harvested from greenhouses that only need low cost LED lights, little in the way of chemicals and water, but still produce multiple harvests during a season.

The use of insects in food was permitted and codified in the EU in 2016 under regulation (EC) No. 258/97(European Parliament, 2016). Recent studies have shown that consumers find insects more appealing when used as an ingredient to prepare foods with familiar flavours and textures or masking their presence in commonly accepted products, like snack bars and chips.[1]

It is becoming rapidly accepted, therefore, to use these creatures in chopped or powder form, to encourage consumption in countries where they are not traditionally eaten. Some benefits of adding insect powder to bakery products include increased content of protein, fat, fibre and minerals, in addition to that of bioactive peptides, delivering anti-hypertensive and antioxidant potential.[2]

An interesting example of some of the side effects of using cricket flour, for example, is that it increases the availability of water to the biopolymers in dough with a consequent reduction of hardness and an improvement in bread consistency. What's more, insect flour brings a newly discovered benefit in sourdough baking which benefits from the effects derived from

fermentation with lactic acid bacteria, which are able to bio-transform flour composition, releasing health related compounds and degrading non-nutritious compounds.

In a recent study on food chemistry, an Italian research team exploited house cricket (*Acheta domesticus* L.) powder (flour), by making a gluten-free sourdough loaf which, when baked, was highly fortified with insect protein. The overall aim of the exercise, was to produce a food prototype that could meet the demands of gluten intolerant consumers and still contain a high protein content. The final product ticked a number of "boxes" and contained: a good source of non-animal protein, the meeting of the needs of vegans, vegetarians and coeliac disease sufferers, in terms of it being gluten-free and above all, the entire process being far more sustainable than more traditional recipes and production methods.

After the study had been completed, the authors of this article analysed the antioxidant properties of the resultant bread by 'radical scavenging', ferrous ion-chelating and ferric reducing antioxidant power assays. A complete volatilome characterisation was also performed by solid-phase microextraction-gas chromatography-mass spectrometry (SPME-GC–MS). The volatilome analysis of cricket bread was originally performed in this work, representing a robust approach to studying the aromatic compounds of foods and improving microbial fermentation during the preparation of bakery products and increasing the quality of bakery goods.

From the results of that research, a statistical, multivariate analysis on volatile organic compounds (VOCs) demonstrated a scenario where sourdough breads fortified with cricket powder were compared to standard commercial sourdough 'control' loaves as follows:

i. similar fermentation performance, with no difference in respect to the abundance of acetoin and acetate, a slightly high level of ethanol and lactate and slightly high levels of 1,4-butanediol

ii. A typical flavour profile created by nuances of hexanoic and nonanoic acid, 2,4-nonadienal, (E,E), 1-hexanol, 1-heptanol, and 1-octen-3-ol, 2,4-butanedione, 2-heptanone, and 3-octen-2-one.

A further benefit of baking bread with cricket flour showed significantly higher antioxidant properties than that made with gluten-free flours alone, particularly after lactic acid bacteria fermentation.

Lastly, sensorial evaluations of cricket enriched breads recorded similar scores to standard ones.

So far, the use of cricket powder has given baked goods a typical aroma, characterised by a unique bouquet of volatile organic compounds, differently expressed depending on the type of starter employed. The addition of cricket flour to baked goods provides sustainable protein with high nutritional value, harnessing beneficial features such as the prevention of oxidative damage.

Considering all the mainly positive attributes described of insect meal, as well as vitamin B12, there are, however, still many problems to be solved regarding cricket farming, with regards to issues related to hygiene standards and technologies for obtaining products intended for human consumption. In some European countries, there are already companies that have managed to develop the farming and production of insect flours on a large scale, whilst being subject to standardisation, compliance with existing standards, the definition of the shelf-life of the product, cost, the toxicity of chemicals

"Bread with cricket flour showed significantly higher antioxidant properties than that made with gluten-free flours alone."

to induce insect reproduction or to contain the insects' overgrowth.

Production costs for insect farming are currently relatively high due research and technologies dedicated to human nutrition still being at an early stage, however, there are governmental grants and concessions available to encourage startups.

Finally, there is an influencing factor among European consumers that needs to change in order to overcome the mental constraints related to the eating of foods containing insects. This may represent by far, the biggest obstacle to overcome and one which will very likely take some considerable time to be accepted by consumers.

Another game of chess anyone?

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EDIBLE INSECTS

The European insect sector and its contribution to the baking world

The International Platform of Insects for Food and Feed (IPIFF) outlines the potentials of edible insects

Written by:

Alice Grassi

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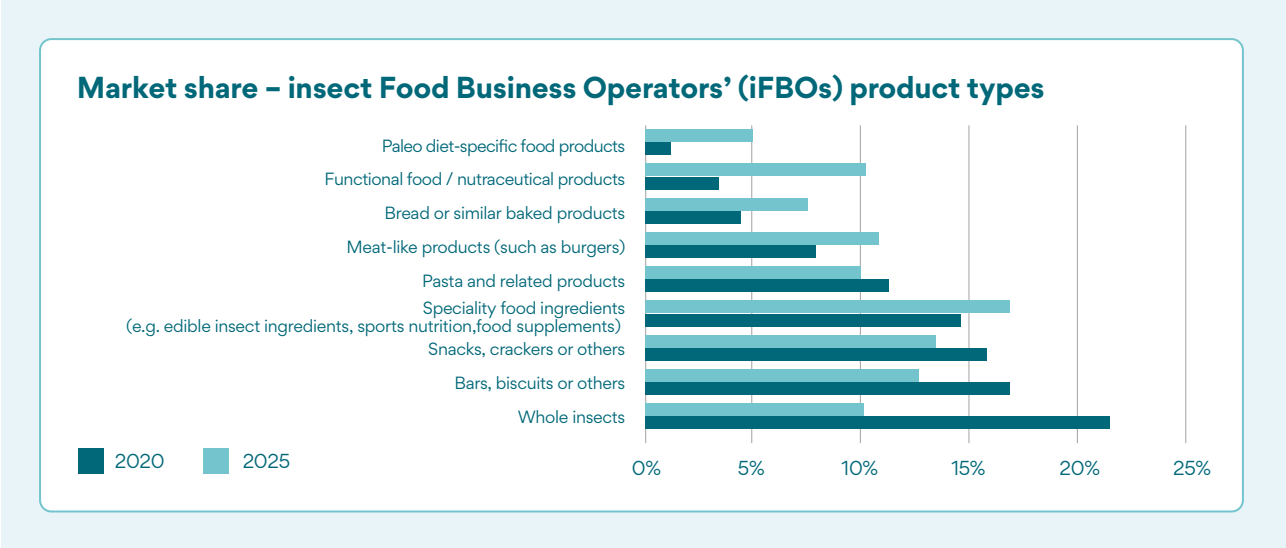
About IPIFF
IPIFF is an EU non-profit organisation which represents the interests of the insect production sector towards EU policymakers, European stakeholders and citizens. Originally created in 2013, the association works in close contact with insect farmers and producers, currently numbering 79 members in 23 countries, in bridging the gap between the sector and EU/ international institutions. IPIFF's main mission is to promote, inform and support the wider use of insects as a complementary source of protein for human consumption and animal feed by focusing its activities around the advocating of appropriate EU legislative frameworks to apply to insect production. Our organisation has, through the years, also integrated academic entities (universities and research institutes) and actors active along the insect value chain (e.g. machinery manufacturers, insect substrates' providers, poultry processors).

Edible insects: an overview
The European edible insect sector is a growing industry. The demand for high protein food for sports nutrition, dietetic food or complementary sources of protein creates further opportunities for the sector.

As shown in the table below, the highest market share today is represented by whole insects (close to a of the products on the market), followed by bars, snacks, speciality food ingredients and pasta. By 2025 it is anticipated that speciality food ingredients will cover approximately 20% of the market, with snacks and bars remaining in 2nd and 3rd place respectively in terms of market share. Despite representing a small share of the present market, it is anticipated that paleo (83%), functional food (75%), baked products (55%) and meat-like products (46%) will have the highest growth rate. The forecast of a potential shift in product representation by 2025 is driven by consumer acceptance, change in socio-cultural aspects (i.e. increasing demand for meat analogues) and product demand. IPIFF believes that the development of the market in Europe will be driven by accessibility, consumer acceptance and regulatory advancements.

Nutritional advantages
The incorporation of edible insects into our dietary habits brings high-quality proteins, but also diverse nutrients that are beneficial for human



metabolism and overall health. Insects are, not only a good source of proteins; they also contain minerals, vitamins, fibre, as well as healthy fatty acids, such as omega-6 and omega-3. Edible insect ingredients such as whole boiled, fried or dried insects, whole insects processed into a granular powder or paste can be incorporated into diverse food products, confirming the versatility of such ingredients.

Sustainability

The sustainability of insect farming is given by its reduced environmental footprint and high efficiency in terms of water and land footprint. Thanks to the vertical farming techniques implemented, insect farming requires less arable land as insect farmers use 'crates' aligned vertically to rear their insects. Most commonly farmed species are able to absorb the water they need from their substrates.

Upcycling underused materials

In terms of their sustainability as an ingredient, insects can contribute to reducing the burden of food waste when they are fed with underused, agri-food by/co-products (e.g. vegetable/fruits/starch origin) or food no longer destined for human consumption such as unsold products from supermarkets, retailers and bakeries, that are scheduled for discard (and cannot be reused elsewhere due to technical/operational reasons). Thanks to their bioconversion properties, insects convert these 'low-value' materials into protein-rich/high-quality products which are now being reintroduced into the food chain. Thus, the local production of such food ingredients not only strengthens agri-food circularity, but also improves regional self-sufficiency.

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1. The table above is part of the IPIFF factsheet on edible insects, 2020.

FOR MORE INFORMATION →

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HEALTHY SNACKING

Can snacking be healthy for you and the plan

Written by:

Alan O'Donnell

Univar Solutions Food Ingredients

Today's health-conscious consumers are increasingly demanding that ingredients are Better for Me and Better for the Planet. This paper describes how delivering sustainable and nutrient-dense, functional products in the bakery sector is becoming the way we do business.

As the world learns to live with Covid, focus intensifies on boosting and maintaining health. Consumers have become "Mindful Nutritionists", educating themselves on what they need for health and what the nutrient density and functionality of their food needs to be. Immunity health has become a fundamental requirement for the considered health-conscious consumer, to enable the prevention of disease or to assist with recovery; consider the research that has linked hypertension, which is exacerbated by high sodium chloride intake, as a risk factor for severe Covid outcomes[1]. Self-care in all its guises, from supporting mental health through to improving the way we look and, therefore, feel have gained more importance for the health-conscious consumer and will continue to guide purchasing choices.

Clean labels are essential in providing the health-conscious consumer with information and, therefore confidence in their chosen products. 'Front-of-Pack' labelling is well established throughout Europe, although less so in the Middle East and Africa. The concept of "Clean Conscience" is beginning to supersede clean labelling, as it goes beyond what is good for the body and reflects what is good for the planet, the provenance of ingredients and their environmental sustainability.

Formulating your recipes in the bakery sector for this new generation

"The concept of "Clean Conscience" is beginning to supersede clean labelling, as it goes beyond what is good for the body and reflects what is good for the planet, the provenance of ingredients and their environmental sustainability."

et?

of health-conscious consumers sounds challenging, you may ask Well, the following might just help.

The healthy bread basket

According to Mintel's 2022 report on Healthy Eating[1], healthy products in the next two years will focus on solutions that support consumers' self-care practices and boost nutrient density, whilst reducing fat, sugar and sodium.

Europe's bakery product market is expected to grow at a compound annual growth rate (CAGR) of 3.12% in the period 2020-2025[2]. Forecasts for the EMEA bread and bread products in Western European areas show this market as mature, with the exception of Italy and Switzerland which will in the future, show steady growth. Strong growth, however, is forecast in the South African packaged bread market.

The pandemic has brought health and wellness products to the fore, with preferences in Western Europe moving towards reduced-fat and sugar as well as a desire for more natural and "free-from" products[3].

Consumers have not until recently, typically looked to the bakery market for healthy sustenance, but the pandemic has resulted in a more hands-on approach to baking (not just banana bread) and, therefore a renewed interest in to what goes into our food and our body.

Consequently, the industrial baker has opportunities to fulfil the increased demands for healthy in-home and

on-the-go baked goods and their inherent challenges on how to deliver them.

Enriched dough

For the Mindful Nutritionist, the definition of 'enriched' has broadened to encompass not only some of the wonderful enriched doughs that produce brioche, poffert and cinnamon buns, but also to include ingredients that enrich the body and mind.

More is being discovered about the significant effects of the gut microbiome on holistic health. "Gut microbiota plays a significant role in maintaining host health, which could supply various nutrients, regulate energy balance, modulate the immune response and defence against pathogens."[4] Offering consumers easy ways to boost fibre intake by its inclusion in baked goods is one way to attract the Mindful Nutritionist who is looking to improve their immunity health.

In terms of formulation for bakery, this can be achieved with functional ingredients such as oligofructose, prebiotic dietary fibres derived from sugar beet and cane sugar; or, fibres from potato or pulses.

"The improper and inadequate nutrition intake through diet have put the elderly at a marked risk of PEM (Protein Energy Malnutrition), affecting about 23-60% of the elderly."[5] Opportunities exist to deliver protein enriched baked goods, that would benefit the health and wellbeing of specific customer groups, including growing children and the elderly, as well as having a wider appeal for the Mindful Nutritionists and their self-care agenda. This could be achieved using whey protein powders, or, if the emphasis is on plant-based ingredients, then pulse, oat and wheat proteins offer versatile ways to increase protein content.

In terms of product formulation, the increasing dominance of the plant-based market means that the ingredient list must show the product's plant credentials, but whilst 'taste remains king', the product still must exceed organoleptic expectations.

Tools to aid the self-care agenda

Across Europe, consumers are being given more information about the health components of the food that they are purchasing. Many European markets are adopting the Nutri-Score, front-of-pack label that provides user-friendly information on the nutritional quality of food and beverages, using five different colours to classify food products into their respective categories. A recent study on the UK's voluntary traffic light system front-of-pack label, supports the making of these labels mandatory. In addition, promotions on food and drinks high in fat, sugar and salt (HFSS) in medium to large UK retailers will be restricted from October 2022.

Every ingredient in every product will need to earn its place on the ingredient list and corresponding front-of-pack labels, contributing to the nutritional component of the product or replacing fat, salt, sugar, or indeed, any specified allergen. Formulating baked goods within this increasingly stringent framework is the challenge of the day, but numerous innovative ingredients now exist to ensure that the products can be successfully formulated to be everything that they need to be. Product developers have a range of functional 'replacers' at their fingertips. In terms of fat reduction, starch-based ingredients, from potato or tapioca, offer water and fat-binding properties, whilst maltodextrins from waxy maize mimic the texture and melt-away of soft fats. Salt-reduction can be achieved using potassium-based or calcium-based leavening agents in place of salt, or flavour modulation systems or alternatively, stevia extracts to enhance the savoury flavour profile. Natural stevia flavour has become a mainstay of sugar-reduction strategies along with sugar alcohols, polyols and fructo-

oligosaccharides (FOS) that offer a prebiotic, lower calorie alternative to sugar. There is a wide range of sweeteners available to replace sugar and, therefore, reduce short sugars with longer sugars. For bakery applications, cereal and dried fruit extracts may provide not only natural sugar reduction, but also additional desirable properties such as natural colour, depth of flavour and crispness.

Sustainable health

Mintel's 2022 report on Healthy Eating[1] suggests that the focus for the next five years will concentrate on a sustainable food supply chain whilst developing ingredients that act on food waste and loss to help mitigate global hunger and food insecurity. A tall, but necessary, order and one that will resonate with the Clean Conscience mindset; requiring clean labels and a minimal environmental footprint. For example, enriching baked goods with proteins derived from pea and bean sources, which offer the least amount of greenhouse gas emissions per gram of protein, is both "better for me" and "better for the planet".

For the baked goods market, consideration must be given to the sourcing and provenance of key ingredients and the impact on social equity and conditions of the growers. This, along with information relating to regenerative, agricultural practices, will in time become part of the consumers' evaluation of the way we do business.

Right now, innovative baked goods' manufacturers have at their disposal solutions for creating sustainable and healthier products. Take the example of naturally occurring and sustainable enzymes which are healthy alternatives for industrial baking. Such enzymes can extend the shelf-life of baked goods, result in improved condition and product quality and improve appearance. Furthermore, since enzymes are typically classified as a processing aid, it is not required to include them in the ingredient declaration, keeping that all important label clean.

Innovative and natural methods to reduce food waste without the need for additional or undesirable preservatives is something that the Mindful Nutritionist will be pleased to hear.

FOR MORE INFORMATION →

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UNDERSTANDING THE U

Creating original formulations for baking

Written by:

Linda Bellekom-Allen

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As a food technologist with a career-long interest in food ingredients and their interactions, particularly food hydrocolloids or gums, I always find 'black box mixes*' to be very frustrating. I can fully understand why a baker in a busy retail bakery making, say, several dozen fruit tartlets, would want a crème pâtissier mix to which you just add water. The result would be consistent in quality, quick and reliable without having to weigh out a large number of ingredients.

This, however, was never for me. I wanted to understand what each ingredient was doing and why it was present instead of another. Therefore, this article is targeted at the development bakers who want to understand the ingredients a little more and maybe stamp their own individuality onto a formulation and maybe even develop a black box mix of their own.

There are a lot of food hydrocolloids from a wide variety of different sources: seaweed, roots and tubers, microbial exudates, tree sap, tree trunks, seeds, fruit skins, animal skins and crustacean shells. Their study in isolation and then their integration into complex recipes, singly or in combination, would be a PhD study of some magnitude. So, what is a development baker to do?

Since I mentioned it above, let's take an example of the approach I would make when formulating the common fine bakery mix, crème pâtissier. I plan to focus on seaweed-based hydrocolloids in this article, so we will consider the properties of

> "I always find 'black box mixes*' to be very frustrating."

USE OF SEAWEED GUM

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.

carrageenan, alginates and agar only, though other gums might also be appropriate. I won't be mentioning other potential uses of seaweed in bakery, which include nutritional supplementation (particularly minerals); the use of seaweed as wraps, like nori; the new developments involving precision fermented algae (though these are really interesting) and laver bread. Regarding this last one, whilst researching for this article I was bitterly disappointed to discover that laver bread is basically boiled seaweed and not a bakery item.

A little background on those three main gums made from seaweed:

Carrageenan

There are several basic types of carrageenan that occur naturally in varying quantities within the genera of seaweed harvested and any carrageenan you receive will always contain a mixture of these types. Manufacturers sell them based on the predominant type found in the seaweed they harvest. Varieties include kappa, iota and lambda; their differences arise from the genus of seaweed used, the geographical location where they grow and the part of the plant used. This affects the sulphate content on the polymer backbone, which in turn affects their gelling ability. The higher the sulphate content the weaker the gel they produce. Kappa has the lowest sulphate content and produces the strongest gel, iota next, then lambda. They require different ions to help them set; potassium for kappa and calcium for iota, lambda gels lightly in milk. Kappa and iota types must be heated to dissolve. Lambda is soluble in cold water and milk.

The kappa gel is firm, but brittle and melts in the mouth; it synereses a bit (loses water). Iota carrageenan gels are more elastic and reform when sheared, which means that you can whip them (think mousses, non-dairy whipped toppings).

Addition levels can be extremely low (as in chocolate milk for kappa carrageenan which is around 0.025%)

"I wanted to understand what each ingredient was doing and why it was present instead of another."

	Sub-Type	Gel or thickening	Dissolution	Conditions Required To Gel	Gel Type	Heat Effect	Applications
Carrageenan	iota	Gel	Hot	Cold set, Ca++ ions	Elastic, self-healing	Melts	Whipped toppings; flexible glazes
Carrageenan	kappa	Gel	Hot	Cold set K+ ions	Clean, brittle	Melts	Clear jellies, milk-based flans, crème caramel, cuttable glazes
Carrageenan	lambda	Thickening	Cold and hot	Gels in milk	Soft in milk only	Milk gel melts	Thickening in drinks
Sodium alginate	High G and High M	Both	Cold and hot	Ca++ ions	Firm	Stable gel	Thickening: whipped toppings Gelling: crème pâtissier, fillings, structured food (fruit pieces); mousses; flans; film formation (liquid drops)
Agar		Gel	Very hot	Cold set	Clean, brittle	Melts	Icings (non-sticky); flans; set custards, flan fillings, crème caramel

to about 0.75% area, sometimes a little higher for very strong gels.

There are further variations based on how they are processed, namely alcohol or potassium chloride precipitation. There is also semi-refined carrageenan, which tends to be cheaper and more clean label (labelled as processed Euchema seaweed), but may need more to be added to obtain the same effect as refined carrageenan.

Alginate

The most commonly used food grade alginate is the sodium salt, sodium alginate. There are other types available, including PGA (propylene glycol alginate), but I am not going to look at them for this application.

There are two basic types of sodium alginate, high G and high M, where the G stands for guluronate and the M is mannuronate. The G part is what forms the gels in the presence of calcium ions; the M gives thickening**. Sodium alginates are both cold and hot water soluble. Though there are techniques involving heat to avoid gelation until it is desired, the calcium reactivity means that you will usually need either de-ionised water in which to dissolve them, or a chelating agent to take up the calcium naturally present in water, milk, fruit juice etc. It will then need a slow dissolving calcium salt to release calcium over time to allow a good set. Frankly, I would rely on the manufacturer to advise on this or provide the blend ready-made.

A combination of high G and high M sodium alginate will provide both thickening and a good strong gel. In common with all hydrocolloids, there will be low and higher viscosity grades available giving different thickening ability.

Once sodium alginate has gelled it is a permanent gel; very tolerant to temperature and acid. Shearing will break it up into lumps which do not reform or melt.

Typical concentrations used will be between 0.5 and 1% depending on its intended use.

Agar

As far as I know, there is only one basic type of agar which must be heated to dissolve and gels on cooling. It will require heating to about 105°C and will gel on cooling to about 35-40°C. Interestingly, it then needs to be heated to about 85-100°C to melt again, which is an unusual hysteresis loop on dissolution, gel formation and melting. There is a lower dissolution grade agar available. The gel is weaker and the dissolution temperature drop is only to about 60-70°C.

Agar gels are formed at quite low concentrations, around 0.2% as a starting point. They synerese, though this can be reduced by adding another gum (like locust bean gum, if you can get it). The gel has a lovely clean, smooth mouthfeel, though it doesn't melt in the mouth.

I am going to ignore all the blends at this point. Synergies occur and these can be used for cost reduction, better stability, manipulating gel types and strengths... but that is another PhD.

So, to the crème pâtissier. Let's start from the functionality required. What is required in crème pat?

1. Creamy, smooth texture,
2. Pipeable in the cold,
3. Re-workable within a given time frame,
4. Bake stable
5. Cold make-up.

That means, to me, a dry mix of starch and milk (or vegan substitute) containing a gelling hydrocolloid.

CREAMY SMOOTH TEXTURE

Carrageenan types
☑ Iota has a slightly rubbery gel, might be suitable at low levels
☑ Lambda would thicken
☒ Kappa might be too gelled, too brittle and prone to syneresis if stirred when set
Alginate
☑ A good smooth texture, particularly the high M type
Agar
☒ At low levels gives a very soft gel, though it still might be too structured

Pipeable in the cold
Carrageenan types
☑ Iota gels are 'self-healing', so once gelled will reform when piped
☒ Kappa gels break up when mixed
☒ Lambda milk gels are soft, no definition to the piping
Alginate
☑ Gel formation can be delayed, so it can be piped before it sets; they hold the definition well
Agar
☒ Breaks up when stirred

Re-workable within a given time frame
Carrageenan
☑ Iota gels would be reworkable
☒ Kappa gels break up
☒ Lambda gels break up
Alginate
☑ This would be time dependent; a gradual set would allow some re-work but this would not be infinite. A good balance of chelating agent and calcium source would be needed to ensure sufficient delay to set. Once set, it is set.
Agar
☒ Probably too firm; on re-working the gel would break to give lumpy uneven or granular structure; syneresis would be a problem

Bake stability
Carrageenan
☒ Even with very high potassium or calcium content which raise the gelling temperature, carrageenan gels will melt on heating
Alginate
☑ Once set, alginate gels are permanent. They do not melt and so are bake stable
Agar
☑ Gelled agar melts at very high temperatures (95-100C). This is possibly high enough for bake stability over a short bake time, but not 100% reliable

Cold make up in water or milk
Carrageenan
☒ Kappa types must be heated to dissolve
☒ Iota types must be heated to dissolve
☑ Lambda types are cold soluble
Alginate
☑ Cold water and milk soluble BUT must have a chelating agent to take up the calcium present naturally in water and milk and a slow-release calcium salt to allow it to set over time
Agar
☒ Must be heated to above 100°C to dissolve

Taking each of those required properties, what would each of the seaweed gums provide? Let's address each in turn and look at what seaweed-based gums might do for them.

So, it's a complex puzzle with different outcomes depending on the application. By a process of elimination, based on the properties needed for a creme pâtissier, you could start with a blend of starch and proteins (milk or other) and a sodium alginate with chelating agent and calcium source present. Alginates are typically added at addition levels in the 0.5% to 0.75% total wet weight of mix.

If you are looking for properties other than cold mix, reworkable, bake stable crème pâtissier, I hope this article will guide you towards a suitable choice of gum for your products and help you in developing approaches for other applications.

I am providing a brief summary sheet here, based on the hydrocolloids of seaweed origin. There are, of course, a lot of other hydrocolloids available, with a range of different properties. If you have a bakery application in mind that might require a thickening or gelling system that is not mentioned here, get in touch. It might require an alternative.

**By black box mixes I am referring to blends where the supplier only provides the list of ingredients and the order of magnitude.*

***Just to clarify this, thickening means making a liquid thicker, more slow flowing; gelling means making it into a solid.*

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In this issue:

Enhancing flavours with natural ingredients
SVZ

Choosing the correct detection system
Mettler-Toledo

Matured dough processing (pre-ferments)
Rademaker

NATURAL FLAVOURS

Enhancing the taste of baked goods by using 100% natural fruit and vegetable ingredients

In Europe, the bakery products market is expected to grow at a compound annual growth rate of 3.12% during 2020–2025 and with this growth showing no sign of slowing down, producers have a good opportunity to innovate. As a result, they are seeking new ideas to meet this evolving demand.

Currently, consumers are increasingly looking for healthier alternatives to tasty treats and baked goods which allow them to indulge, while still meeting their broader health goals. However, whilst catering to the health-conscious consumer is still of paramount importance, taste remains king. So, what can producers do to create great-tasting bakery products using natural, nutritious ingredients?

Bolstering bread flavours

The UK bread market alone is worth $6.9 billion. To gain commercial success, with so many types of bread product on the market, product development teams are looking for exciting twists on existing products. This could be achieved, for example, by adding natural ingredients like vegetable purées to tortillas: it would be a great way to amplify a product's flavour profile without overwhelming consumers who are still seeking a nostalgic taste.

As many people "eat with their eyes" first, properties like natural colour should also be considered when attracting consumers. Take spinach purée, for example – not only could it add a new flavour to a wrap, but the vibrant green colour would stand out on supermarket shelves, therefore, catching consumers' eyes. With its earthy sweet taste and unique pink colour, red beetroot purées or concentrates would be another great way of adding flavour and colour to a product without the use of e-numbers or artificial colourings.

Catering to the sweet tooth

Meanwhile, cake consumers have recently revealed their adventurous side with 44% saying they would experiment with flavour choices. There are plenty of natural fruit and vegetable ingredients that could be added to create unique, mouth-watering cakes and sweet treats – while also adding a nutritional boost. Raspberry, cherry and strawberry ingredients are a popular choice for use in cakes, muffins and cookies and with the use of single strength purées and juice concentrates, producers can replace added sugar with natural and authentic fruit.

For people with a more daring sweet tooth, lychee adds a unique flavour. By incorporating lychee juice concentrate into baked goods, producers can create a mouth-watering citrus option to differentiate from classic varieties. Similarly, more unusual fruity flavours could be introduced with a nutritional boost, by using berry blends. Mixing

"For people with a more daring sweet tooth, lychee adds a unique flavour."

blueberry, redcurrant and cranberry ingredients together, for example, can deliver both great taste and excellent health credentials.

Delicious, sustainable *and* circular

In addition to demanding new flavours and searching for healthier ingredients, consumers are becoming more aware of the effect that the food they consume has on the planet's health. Sustainable fruit and vegetable ingredients will only become more popular when manufacturers seek to meet rising demand for responsibly sourced, healthier foods and beverages.

Sourcing fruit and vegetable ingredients that are as tasty and nutritious as possible – while simultaneously shifting to a circular and more environmentally responsible way of growing with reduced reliance on chemical pesticides, can be challenging. That's why the expertise of agronomists is so crucial – so that this shift to 'greener' agricultural methods can take place without any compromise on the quality of the fruit.

For one Dutch ingredients' company, agronomy is seen a fundamental part of its sustainable approach to agriculture and a way to provide manufacturers with the very highest quality of fruit ingredients. By pioneering 'greener' farming initiatives like the introduction of biodegradable mulching paper, the company is looking to the future and working towards more circular agricultural processes.

Conclusion

With the evident pressure to meet evolving consumer needs, product development teams should rely on high-quality, sustainable and 100% natural fruit and vegetable ingredients to deliver on both label-friendliness and taste. Whether it is for sweet or savoury applications, these 'health halo' ingredients are easy to incorporate and add a new dimension of authentic, delicious flavours to traditional baked goods.

Source: *Johan Cerstiaens, SVZ*

The right choice for product inspection

METAL DETECTION,

Written by:

Ian Robertshaw

Global Key Account Manager, Mettler-Toledo

Both metal detection and x-ray systems play key roles in product inspection for food and pharmaceutical companies. Choosing the right technology requires the consideration of many factors – starting with the intended application.

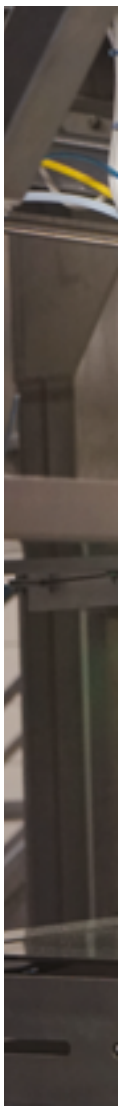
A layman might consider it an easy choice: if you are looking for the best inspection technology designed to detect metal contaminants, get a metal detection system or if you are looking for a system to detect both metal and non-metal contaminants, choose an x-ray inspection system instead.

There is a kernel of truth in this supposition, because very often, such as with aluminium and wire, a metal detection system will be better at detecting metal than an x-ray system.

"Careful consideration must be taken when choosing whether to equip production lines with metal detection, x-ray technology, or both."

However, the right choice is not necessarily so straight forward, for example, what if you need to identify metal contaminants, but the product is packaged in aluminium foil? The foil is seen as a detectable contaminant by a metal detection system, so in this case, metal detection would not be suitable. So, in reality, though not the obvious choice, an x-ray system that sees straight through the foil to detect contaminants would be better suited to the task.

This choice of technology is not simply about the type of contaminant being looked for, it is also about considering where in the production process the product should be



X-RAY – OR BOTH?

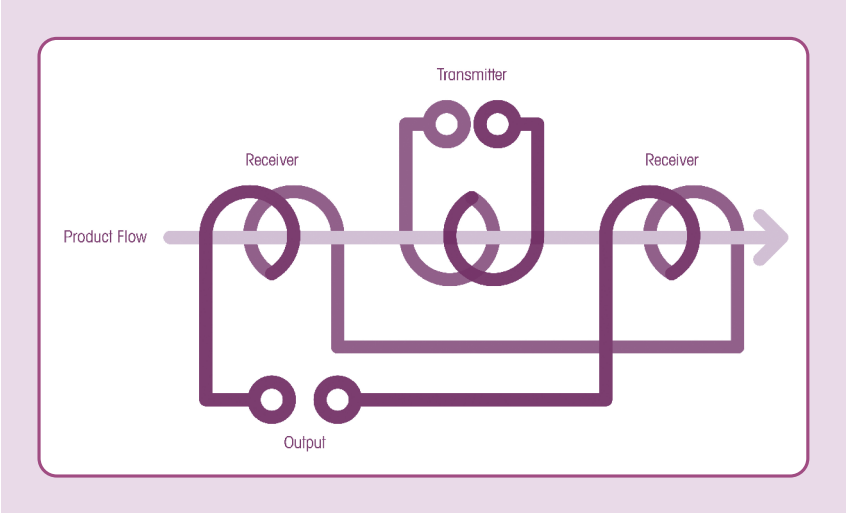
inspected: if raw product needs to be inspected before other valuable ingredients are added, then, in theory a metal detection system would be best. Even so, bear in mind that for end-of-line inspection, where packaging integrity checks are required, as well as contaminant detection, then x-ray technology would be more suitable.

What is certain is that product inspection is a critical part of the food production process, ensuring that consumers can have confidence in the quality and safety of the products they buy. Therefore, for food manufacturers, careful consideration must be taken when choosing whether to equip production lines with metal detection, x-ray technology, or both.

There are fundamental differences in the way that metal detection and x-ray inspection technologies work, so it is important for food manufacturers to understand what these differences are and how they can have an impact on the ability to perform optimally on certain product inspection applications.

Here the word 'application' really is key: the nature of the product, the fill process (i.e. Vertical Form Fill Seal -VFFS), the potential contaminant types and factors such as the physical packaging, must all be brought into the equation when selecting the right contaminant detection technology. In addition, constraints on finance and physical space and the range of additional quality control checks should also be taken into consideration.

Metal detection
Modern metal detection systems can identify all metallic elements and alloys, including ferrous (e.g. chrome and steel) and non-ferrous (e.g. brass and aluminium), as well as magnetic and non-magnetic stainless steels. They work through a system of coils, charged with an electrical current to create a balanced electro-magnetic field. If a product passing through this field contains a metal contaminant, the magnetic field is disturbed, this disturbance is then interpreted by sophisticated electronic circuitry and software algorithms, flagging the contaminated product to the manufacturer.



A well-designed metal detector for use in the food industry is able to detect a pinhead in a loaf of bread, whilst a detector for pharmaceutical applications can detect metal contaminants with a diameter of less than 0.3mm. In order to perform as these industries demand, the detector construction must be stable and rigid enough to eliminate any movement of the coil system, as even tiny vibrations can cause the rejection of perfectly good products. Airborne electrical noise can also be problematic, so it is essential for the metal detector to be designed in a way that enables it to be operated reliably in a factory environment.

The product effect
When it comes to inspection capabilities, metal detection is especially suited to dry products,

> "Both metal detection systems and x-ray inspection technologies have strengths and weaknesses in the field of product inspection."

where the lack of moisture means the product is non-conductive and, therefore, does not generate a significant 'product effect'. Products with a high moisture content or those that are salty or acidic, are conductive, so as they pass through the metal detector, they will emit a signal (i.e. the 'product effect') that disturbs the detection field.

Product effect is a major factor leading to high false rejection rates. As well as the moisture or salt content of the product, other factors that contribute to product effect are: product temperature, format, consistency, size and shape as well as its orientation on the production line.

Manufacturers can eliminate the impact of product effect by installing a high-quality metal detection system that uses a combination of multi-simultaneous, frequency operation and software algorithms to optimise performance and reduce the possibility of costly false rejections. This technology will also result in the system having the right level of sensitivity to pick up signals from very small metal contaminants, irrespective of the application and provide the highest level of brand protection.

In addition to packaged products, other applications where metal detection can be used include: loose, unpackaged products, pumped products such as liquids, pastes and slurries, bulk powders or free-flowing solids under gravity-fall conditions. Furthermore, tall, rigid containers such as bottles, jars and composite containers can also be inspected. Although in these applications, inspection would need to take place before a metal cap or closure were applied.

Type of packaging

Metal detectors using multiple frequencies simultaneously or operating at a single low frequency, can usually be used with products packed in metallised film packaging, depending on the film thickness. If aluminium foil packaging, such as foil wraps or products trays are to be used, then the standard balanced coil metal detectors would not be suitable.

X-ray inspection

X-ray inspection systems have the capability to detect a wider range of contaminants than metal detectors, including metal, glass, stone, calcified bone, high-density plastics and rubber. They can also perform a range of additional in-line quality checks on food and pharmaceutical products, such as measuring mass, counting components, identifying missing or broken products, monitoring fill levels, detecting product trapped within the seal and checking for damaged product and packaging.

The technology works by generating an x-ray beam that passes through a product for inspection and onto a detector. Some of the x-ray beam is absorbed by the product and any contaminant present and because most contaminants are denser than the food and pharmaceutical goods that are being inspected, the contaminants usually absorb more of the x-ray energy. This difference in absorption becomes apparent in an image generated by the x-ray system, which is then compared to a pre-determined acceptance standard. The product is accepted or rejected based on this comparison. When rejected, the system sends a signal to an automatic rejection system, which removes the offending item from the line.

However, whilst x-ray can easily detect these dense contaminants, with low density contaminants such as insects, wood and polyethylene film, detection by x-ray is not possible. Nevertheless, x-ray systems are able to inspect a wide range of different product types, notably pumped products such as slurries, fluids and semi-solids, bulk, loose products, jars, bottles and cans and packaged products, including those utilising foil or metallised film.

Which technology?

As already noted, both metal detection systems and x-ray inspection technologies have strengths and weaknesses in the field of product inspection. The process of choosing the right one involves going back to the application and carrying out a Hazard Analysis and Critical Control Points (HACCP) or Hazard Analysis and Risk-Based Preventive Controls (HARPC) audit. This will identify what risks of contamination there are with your application and what types of contamination are likely, as well as providing a greater understanding of the requirements of any customer or compliance related issues.

Critical Control Points (CCPs) should be established to mitigate the risks and product inspection equipment needs to be installed at these points. If the HACCP/HARPC audit determines that metal is the only likely contaminant, then a metal detection system is probably going to be the best solution.

If metal and/or other contaminants, such as glass, stone or dense plastics, are likely to be encountered, then x-ray would be the better choice. This decision is not black and white or made on the balance of probabilities, as there are many applications where the right choice is unclear and others where the right idea might be to deploy both metal detection and X-ray systems to achieve the desired level of quality control.

By way of example, below are some scenarios that highlight the need for a certain system depending on which contaminant might be present:

Aluminium contaminants in non-metal packaging: as a lightweight, low-density metal, aluminium is hard for x-ray to detect as a contaminant; metal detection is generally the better solution.

Metal contaminants in aluminium foil packaging: metal detection will be unable to spot the contaminants amidst the foil packaging unless it is a metallised film; x-ray is generally the better solution.

Metal contaminants in gravity-fed products: x-ray does not work well with falling, accelerating objects that do not have a uniform direction of travel; here, metal detection is the only viable solution.

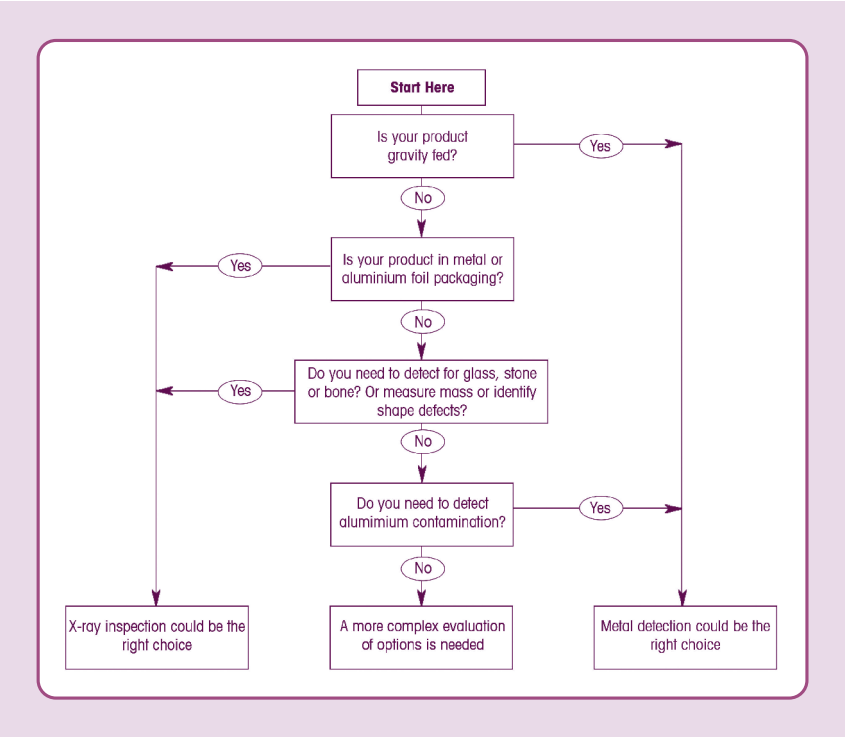
Metal contaminants in non-metal packaging: this can be a complex issue. Metal detection systems are more cost-effective, but if the product is very large, a bigger detector aperture would be needed, which can reduce the sensitivity of the detector. Multi- and high frequency technology can improve sensitivity, but a bigger metal detection system would be required. X-ray power can be increased for larger products, but the cost of installation increases with products size. If there is a need to protect against non-metallic contamination, the choice would swing towards x-ray.

Non-metal contaminants in any packaging; performing additional quality control issues: x-ray inspection is the only solution; the additional quality control checks required, justifying the additional cost of the technology.

Fast/variable line speeds; situations where there is limited space: metal detection (at 400m/min) is able to inspect at faster speeds than x-ray (120m/min), so may have the advantage if other aspects of the application suit metal detection better. Metal detectors are also less space-hungry than x-ray, so depending upon the application, they might be more suitable in factories with limited space.

Making it simple

Metal detection or x-ray? The flow chart below is a good starting point for identifying the most suitable product inspection system for a food manufacturer. However, there is need for deliberation where the application is not packaged in foil and where metals other than aluminium are potential contaminants. As the chart shows, in these scenarios a more complex evaluation of options is needed.



There may also be situations in which more than one type of product inspection system is desirable at different CCPs on the production line: it may be wise to install a metal detector early in the processing line to remove large metal contaminants that could, if left in place, cause damage to machinery downstream or fragment into smaller and less easily detectable pieces. Further down the production line, an x-ray machine could then check for non-metal contaminants, as well as carrying out further quality control checks, whilst a second and more sensitive, metal detection system at the end-of-the-line could be used to make a final inspection for smaller metal contaminants.

In closing, it is worth reiterating that the first step in choosing a metal detector or an x-ray system for product inspection is to consider the application – the type of product, the type of likely contaminant and the location of CCPs. Metal detection offers many advantages for raw product inspection, whereas x-ray inspection provides multiple product and packaging integrity checks, in addition to contaminant detection. Finally, it is worth remembering a good many more factors will influence decision making, including space limitations, total cost of ownership and productivity targets, but the fact remains, the application is where the assessment ought to begin.

FOR MORE INFORMATION →

METTLER TOLEDO

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MATURED DOUGH PROCESSING

(pre-ferments)

Background

As far as we know, the first loaf based on a sourdough was made by hand in Egypt 7,000 years' ago. Thereafter, bakers proved breads by using yeasts from beer or that was originating from distilleries. The resultant duration of dough preparation and proving was considerable by today's standards, taking around 12 hours and for that reason encouraged contemporary bakers to search for much quicker proving processes in order to save production time. About 150 years' ago, Louis Pasteur discovered that yeasts were classed as a type of fungi and that during dough fermentation they produced a kind gas.

Whilst more than 100 different species of yeast are known today, there is just one group that is

particularly well suited for its use in baking. This yeast family, known as Saccharomyces cerevisiae, consists of several disparate strains. Since the 19th century, the proving process using these strains has accelerated to produce the commercial yeast we know today.

Although there have been improvements in the process of commercial bread making, the average time from flour to baked product being just three hours, it is alarming that in recent years there has been an increase in the number of people suffering from related allergies. As the medical world reacts to such health issues, the question that follows is: could sourdough bread be easier to digest than today's bread made with commercially produced yeasts? In this article we will take a closer look, considering the differences between the use of yeast against sourdough and how easily the latter can be produced successfully and efficiently on a production line.

"It is alarming that in recent years there has been an increase in the number of people suffering from related allergies."

The different ways of maturing dough

Artisanal style baking can be undertaken without the use of commercial yeast but this can only be achieved with the use of sourdough. Conversely, bakers in a factory environment producing mass quantities of bread, need be highly skilled to control the proving process due to it is highly complex and unpredictable properties. It is common, therefore, for many bakeries to use a small amount of cultured yeast to serve as a supporting leavening agent, in combination with the sourdough itself in order to render a more stable dough suitable for large-scale production. Whist this may make sourdough purists wince a little, it is an ideal way of producing high quality ("sourdough type") breads consistently and cost efficiently.

Dough maturing

There are many ways to mature doughs, one of the most common being the so-called "biga", which is a solid dough that needs to mature for 24 hours, its proving process mainly controlled by enzyme breakdown. Another example is a Poolish, which is essentially a, high hydration pre-dough, activated with yeast for subsequent addition to the main dough mass; a process widely used in the pizza industry. Finally, there is the process of allowing a complete dough to mature, also called a mother dough such as 7-day croissants.

The acidity of the sourdough

There are some limitations as to how much pre-ferment should be added to the dough mass owing to the different types; too much, for example, lowers the pH of the final dough. In general, a very long bulk fermentation duration requires a lower proportion of pre-ferment and vice-versa, in order to obtain a good quality product. When baking bread based on a sourdough, the isoelectric point of gluten proteins of pH 4.4. should be taken into consideration to control correct acidity of the dough. When a dough falls below this level, gluten proteins lose their functional properties such as gas retention, which can render the dough sticky and unmanageable.

The proving processes

A sourdough product goes through a long proving process whereby gluten is broken down making the bread more digestible than a yeast dough and which has a shorter proving time. In addition, the longer proving process ensures that a larger part of the phytic acid breaks down, making minerals such as iron and zinc more available for absorption, not forgetting that sourdough products lend themselves very well to E-number free and clean label products.

The taste of sourdough
During fermentation, a deliciously authentic flavour is created as some of the carbohydrates are converted by the bacteria to lactic acid, acetic acid and CO_2, whereas in a limp, warm dough, it is mainly lactic acid bacteria that are formed. In solid and cold doughs, very weak acids increase in quantity (mainly acetic acid bacteria), both of which affect the final taste of the product.

Many doughs are cooled back to 10°C and then processed. During the long proving process a relatively large quantity of water is absorbed by the flour, resulting in a soft bread crumb and a longer shelf life. Increasing the water percentage in the dough does help to create an open bread structure. A word of caution, however, a sourdough must be treated delicately and gently to keep the nice open structure in the baked product, necessary care will lead to a well baked sourdough bread that has a nice crispy crust and a wonderful taste.

Law regarding (a starter culture of) sourdough
The laws and regulations regarding sourdough differ from country to country and in some instances the word "sourdough" is a protected name. These laws mainly relate to the process and naming of the product, but there are also countries that have no related laws. If you have questions about the legislation of sourdough for your country we would be more than happy to advise.

Rademaker

This article has been written in partnership with the Rademaker Academy

The International Platform of Insects for Food and Feed presents:

New Horizons for insect farming

The role of research and innovation in strengthening cross-border collaboration

MAY 13, 2022 | 2PM-4PM (CET)

ONLINE WORKSHOP

ipiff

The use of SUPERCHILLING to achieve energy savings in the bakery industry

Written by:

Greg Jones

Gary Tucker

Campden BRI

Superchilling (also known as 'Deep Chilling' or 'Crust Freezing') is the practice of chilling a food product to the point where only a fraction of the liquid within is ice, to deliver extended shelf-life without compromising quality (around -1.5 to -2.0°C). This practice is well established in certain sectors of the food industry (e.g. poultry) and easy to achieve using standard mechanical refrigeration.

In the bakery industry, superchilling is not reported to be widely adopted, possibly due to rigid adherence to definitions of 'chilled' and 'frozen', which is mirrored in other sectors of the food industry. The UK Government requirements are for chilled foods to be transported and sold below 8°C with a recommendation for setting fridges at 5°C to ensure that 8°C is achieved1. Frozen foods are recommended to be stored at -18°C with -12°C as a maximum temperature to ensure thawing is kept to a minimum. By considering a third option, 'superchilled', a more flexible and sustainable route to market can be achieved.

Superchilling is a process that is tailored to the food product. This is because different food products have different freezing points depending on the levels of free water in the product. Ingredients such as salts and sugars depress the freezing point by binding the water and making it harder for that product to freeze. Bakery products are a good example of a food product that will have a relatively low freezing point compared with most food products.

A recent success story in the application of superchilling comes from a producer of cook-chill prawns, a high-water product that freezes just below 0°C. Instead of making many small, chilled batches of product in response to individual orders, the manufacturer now makes larger batches which can be stored for longer at superchill, before being released into the chill chain. This practice of making for stock rather than order, has resulted in significant savings in energy and water use (around 20% for each), as well as the obvious reduction in wasted product due to start-up and shut-down losses. The storage time at superchill has been carefully assessed to result in a chilled product which to the customer is no different to any other.

For the baking industry, similar advantages can be expected for

"It is entirely possible that superchilling can extend the shelf-life of chilled products without impacting on product quality."

companies producing products which are distributed chilled, such as pies, quiches or puddings. The changes that occur during shelf-life are mostly governed by microbiological growth and water movement between different components within the product. Dropping the storage temperature to just above the product's freezing point slows both these changes down. Several major producers of such products are actively exploring the benefits of superchilling and it is not unreasonable to assume that an increasing number of chilled baked or part-baked products on the market will soon be dispatched from superchilled warehouses.

The advantages of superchilling doughs and batters are less clear. It is entirely possible that superchilling can extend the shelf-life of chilled products without impacting on product quality. However, the length of time a dough can be kept superchilled whilst retaining the final quality of a chilled product is unknown and would have to be determined experimentally (see Figure 1). The same applies to doughs that would otherwise be kept frozen.

There are several raw bakery products that could benefit from a longer chilled shelf-life. Examples include batters and doughs that are sold between businesses with current shelf-lives of up to five days. Factors that dictate shelf-life tend to be growth of microorganisms that are able to grow slowly at chilled temperatures. These include yeast, lactobacilli, Listeria and several other bacteria with potential to cause spoilage. Pizza dough is an example of a product that is manufactured in bakeries set up specifically to mix and process dough at large scale. The dough is chilled to slow down yeast activity and keep microorganism growth generally under control. It is then transported chilled to the facilities that store and use the dough to make pizzas. One of the challenges is avoiding the dough becoming too lively through increased yeast activity. This changes the crust and crumb properties of the baked pizzas. Yeast becoming too lively is the main problem with chilled pizza dough. However, on occasion, bacterial growth can occur which can lead to spoilage of the dough through action of the enzymes generated from bacterial growth. The potential increase in shelf-life through superchilling dough could improve the consistency of the end baked product, delivering economic value.

A pizza or bread dough will have a freezing point several degrees below zero compared to a meat or fish product. This is because of the dough's lower water content and the

presence of cryoprotectant ingredients such as sugars and humectants. Microbiological growth below zero will slow down considerably. Water movement will also slow because of the increased viscosity of the sugar solutions at lower temperature. This will extend the shelf-life beyond what is currently achieved.

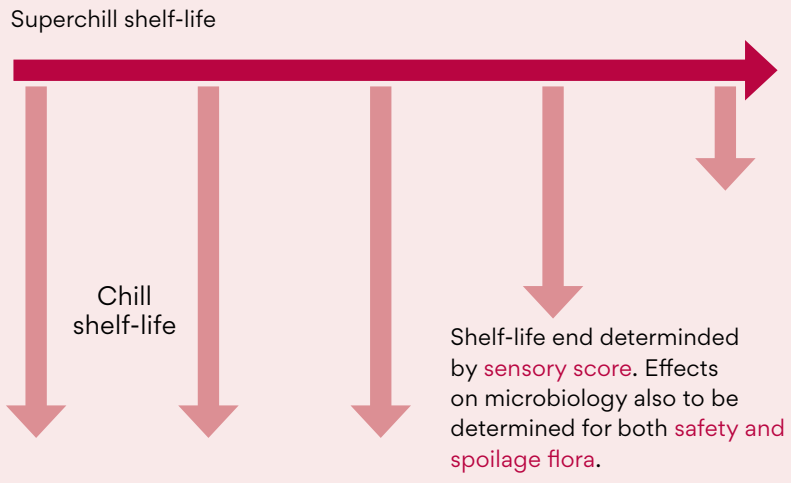
Another bakery sector that might benefit from superchilling is the frozen pastry and cookie dough market. Frozen products are viewed by consumers as lower quality than chilled, even though there is evidence to suggest this is not always correct.

"The advantages of switching to superchilling multiply as one considers the flow of product through a factory."

Chilled products therefore tend to command a higher price than frozen, making them attractive to manufacturers. If a longer shelf-life can be achieved using superchilling instead of freezing, this technology becomes more attractive. It remains to be seen how long the superchilled shelf-life of a raw bakery product could be. Challenge testing can provide the answers, using a suite of microorganisms that could grow under the storage conditions.

For producers of finished products designed to be stored and distributed frozen, the advantages of switching to superchilling multiply as one considers the flow of product through a factory. It is estimated that for such products, 32% of total energy consumption is attributable to the freezing process itself (Therkelsen et al 2014), with energy costs from storage at -18°C on top of the production costs. Superchilling will speed up production lines by reducing the dwell time in spiral or tunnel blast freezers, allowing more products to be produced in a shorter period of time. This reduces the amount of energy used by the blast freezer. Subsequent storage will also consume less energy, as the storage facility will be running closer to ambient temperature (indeed, it may be above ambient temperature in

Figure 1: Experimental approach



areas far enough from the equator). The key change that makes this process energy efficient is side-stepping the intensive energy requirement involved in converting water into ice. Superchilling deliberately avoids this by using temperatures close to the freezing point, but not below.

Similar energy benefits will also be apparent for products usually dispatched frozen for finishing in on-site ovens. In addition to the savings in production energy costs, there will be a shorter and more economical bake in-store as the product arrives several degrees warmer and without ice.

Superchilling offers the baking industry a cost-effective way to reduce waste and energy usage, extend shelf-life and improve quality. It is easy to adopt, as no significant outlay in new equipment is required and there is no legal barrier to implementing the practice. The only challenge will be for suppliers and their customers to effectively work together to change specifications and working practices to take advantage of this simple and cost-effective technique.

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FOR MORE INFORMATION

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SAFE AND SUSTAINA

for bakery products, sweet and savoury biscuits

Written by:

Vera Fritsche

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Automation, hygiene and sustainable packaging are playing an increasingly important role when it comes to packaging baked goods and biscuits. Flexible, fast and sustainable packaging technology is what is needed for today's food manufacturers.

Longer shelf life and convenience are driving demand for packaged baked goods such as bread, cakes as well as frozen baked products. According to Euromonitor International, consumers worldwide purchased 71 million tons of these goods in 2021 with demand expected to increase by a total of 8% to 77 million tons by 2025.

Globally, "snacking" trends are on the rise with millennials in particular, reaching for sweet or savoury biscuits at least once a day as a snack between meals. The importance of snacks will continue to grow in the coming years with forecasts predicting sales of sweet and savoury biscuits increasing by a total of 9% between 2021 and 2025.

All these products contain ingredients such as gluten cereals, eggs, peanuts, soy, dairy, nuts (almonds, hazelnuts, walnuts, pistachios, etc.) all of which can trigger allergies in many people, some of them being potentially life-threatening. This is due to an increasing number of people worldwide suffering from food allergies and intolerance, with estimates suggesting that more than 250 million of whom have a food allergy. According to the Asthma and Allergy Foundation of America

"Longer shelf life and convenience are driving demand for packaged baked goods."

ABLE PACKAGING

(AAFA), 32 million Americans have food allergies; the situation in Europe being similar.

In the EU, labelling of the 14 main allergens is now mandatory and, as such, manufacturers are now obliged to include them on the product label. If the product is free from such ingredients, the producers will label them with the words: "free from". This means that the producer is under an obligation to ensure this product is 100% free of the stated ingredient which is a challenge, since the increasingly strict regulatory conditions regarding food safety, must also be met. Hygiene requirements in production and packaging are still very high.

Manufacturers are launching an ever-increasing variety of packaged baked goods and sweet and savoury biscuits every year, however, this means that the batches of the respective product are decreasing. Producers, therefore, need to clean their machines and equipment more frequently, but also with enough speed and efficiency to minimise the downtime that can occur during product changeovers. (Please see article in this issue on plasma cleaning on page XX).

Product safety through Hygienic Design

When two similar products are packaged on the same machine consecutively, the first with nuts and the second without, for example, the entire packaging line must be cleaned thoroughly after the first product to

ensure that no traces of allergens whatsoever can be transferred to the subsequent product. The risk of product contamination or cross-contamination must be eliminated at all costs so as not to endanger consumer health. To reduce this risk significantly, it is vital that the machines used are designed in accordance within current Hygienic Design guidelines since such design eliminates corners and cavities where product residues, microorganisms or dirt can accumulate. This results in less cleaning effort, shorter downtimes, minimisation of material waste and a significant increase in plant productivity.

Optimising cleaning processes is also very important, for example, CIP (Cleaning in Place) processes are very much in vogue. They are constantly being developed to avoid over dimensioned cleaning processes and at the same time ensure maximum safety; CIP sensors, for example, indicating when cleaning is required. This saves water, cleaning products and energy, protects the environment, lowers costs, reduces downtimes and increases efficiency, without compromising safety.

Flexibility for fast product changes

The range of biscuit types and designs has ballooned in recent years whether they be plain, include fillings, chocolate coatings, are decorated with sprinkles or cocoa chips, to name but a few, with the savoury varieties also expanding rapidly. Every year, an unmanageable number of new products enter the markets: new flavours, shapes, different portion sizes and, with it, a wide variety of packaging sizes and designs. This growth is creating an increasing demand for fully automated, customised packaging systems to increase productivity, reduce labour costs and enable hygienic processing. As manufacturers often process different products on the same line, the packaging machine needs to be

"Retailers and producers are coming under pressure from consumers, who are demanding products be wrapped in sustainable packaging that can be recycled easily."

extremely flexible and be able to change quickly and easily to new formats to accommodate different packing styles and configurations for biscuits. Automatic packaging technology designed for maximum flexibility and speed and importantly, the gentle handling of products, also enables producers to adapt quickly and promptly to consumer needs. An increasing trend is for smaller packaging since consumers are showing that they prefer handier, pocket sized individual portions packed in multipacks so that they can always enjoy their snack fresh.

Detecting and rejecting defective products

Only perfect, undamaged packaged baked goods and biscuits should reach the shelves of supermarkets and discount stores, therefore, it is important to detect defective products as early as possible in the process and to exclude them from further processing. Some common faults in this vein may include "is the biscuit really filled or did the cream filling go wrong? Is the cookie broken or is it damaged? Here, for example, X-ray scanners are used to check the baked goods for integrity and completeness and to detect rejects for removal.

Sustainable packaging

Approximately 80% of all baked goods and biscuits sold in retail outlets worldwide are packaged in plastic packaging the most dominant being the flexible type such as pouches (Euromonitor International). The remainder comprises rigid plastic packaging such as trays or smaller plastic containers, with paper-based packaging accounting for just 16% of bakery and snack packaging sales in 2021.

Biscuits are classic on-the-go products, bought spontaneously and often eaten whilst on the move. The convenience of the packaging plays a major role here in that it must be easy to open and, above all, easy to reseal. The issue of sustainability is also playing an increasingly important role to comply with current legislation and the demands of retailers who are demanding that producers offer their products in sustainable packaging. In turn, retailers and producers are coming under pressure from consumers, who are demanding products be packaged in sustainable packaging that can be recycled easily. After all, it is they who decide at the point of sale whether or not to buy the product based on such qualities.

By the end of 2018, leading global brand owners had already signed a "New Plastics Economy Global Commitment", in which they pledged that by, 2025, all plastic packaging should be 100% reused, recycled or composted. To achieve this goal, they are relying on plastic packaging made chiefly from mono-materials, to enable it to be sorted easily and returned to the cycle. Another approach to more environmentally friendly food packaging, is to use that made from renewable raw materials, the most obvious, of which, is paper. There are a number of new developments in the field of paper-based packaging, such as tubular shaped bags or trays made from cardboard instead of plastic even for delicate products such as biscuits.

Folding cartons that are currently benefiting from the strong demand for snacks of all kinds, whether they be savoury or sweet. The proportion of paper-based packaging used in the industry for these products is around 70% with forecasts predicting that widespread demand will increase by a total of 8% in the next few years. (Euromonitor International)

New packaging materials require machines with increased flexibility allowing quick conversion to other packaging materials so that both plastic and paper or cardboard packaging can be processed on them. Furthermore, mechanical engineering enables the conversion of existing machines and lines currently on the market to allow paper-based packaging materials to be processed. Good packaging solutions require know-how of packaging material, product and machines therefore, it is important for the machine builder to work closely with packaging material and consumer goods' manufacturer.

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REGULAR AND GLUT
AT THE SUPERMARKE

What their packages show and why they are chosen?

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Food choice and its investigation in a simulated context

When considering food to buy in a supermarket, consumers are influenced by several factors ranging from label information, brand and price to the consumer's knowledge and experiences[2]. With regards to the product's intrinsic properties, the food industry uses different labels and packages to attract consumers' attention to their product, especially in a supermarket aisle, where consumers might find different options for the same product. Packaging can also provide information that will help consumers decide whether or not to buy a product, for example, it can have a logo that provides information e.g. where the product contains gluten, which is important for anyone who is coeliac as they will be looking to effectively manage their condition. It also worth noting, that besides health, as we age our choice of what to eat changes with us.

When studying this food choice, a

> "In this style of simulated purchasing exercise, participants´ behaviour can be analysed by direct observation."

EN-FREE BISCUITS
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supermarket style environment can be one of the most effective ways of accumulating data. The use of simulated supermarket environments (products arranged on a store shelf or aisle) allows participants to get immersed in the purchasing experience while researchers can control the environment, meaning that no unexpected interruptions will occur, or the product can be displayed and adapted freely according to the needs of the research. In this style of simulated purchasing exercise, participants´ behaviour can be analysed by direct observation. Nowadays, researchers can go even deeper and know what the consumers are actually looking at.

An **eye-tracker** has now been developed, allowing researchers to follow the eye movements of the consumer. To further understand food choice, interviews can be used, for example, the **laddering interview.** This technique consists of a series of follow-up questions that help to unravel the "Attribute", "Consequence" and "Value" of purchasing decisions. In short, several techniques should be combined to get a true picture of what really influences consumer choice.

An example case study: Purchasing considerations for coealic and non-coeliacs

120 people took part in a study, each person belonging to one of four different groups: coealic and non-coeliac children (8-13 years old) and their parents. All participants were asked to "purchase" biscuits, either for themselves (children) or for their children (parents), in a simulated supermarket aisle that included twelve commercial biscuit types, six gluten-free and six regular types. This purchasing activity was performed wearing eye-tracker glasses. The results are summarised on the next page in Figure 1.

The eye-tracker results revealed that most of the participants looked firstly at the biscuit image and the product name. A minority looked firstly at the

Figure 1. Experimental setting

cartoon character on the packaging and less than 20% at other elements.

At the end of this purchasing task, all the participants had looked at the biscuit image and the product name at least once. Most of them also looked at the cartoon character and brand name (70%). Price and gluten-free words were observed by 40%-75% of participants, depending on the group. The certified gluten-free symbol and the list of ingredients, captured the attention of 20%-49% of participants, with differences among groups.

How age and the coeliac condition affected consumer behaviour

As can be observed in Figure 2, coeliac children focused significantly more on the list of ingredients, gluten-free words, and gluten-free symbols, than the non-coeliac children. Furthermore, coeliac children focused a lot less on the biscuit image than the other children and it was observed that the profile of fixations of gluten intolerant children changed little from their parents, whereas for others it differed greatly from their parents.

Parents of coeliac children also showed differences from other parents by focusing less on the biscuit image, product name, cartoon character and nutritional information, and placing more attention on the list of ingredients and on the certified gluten-free symbol.

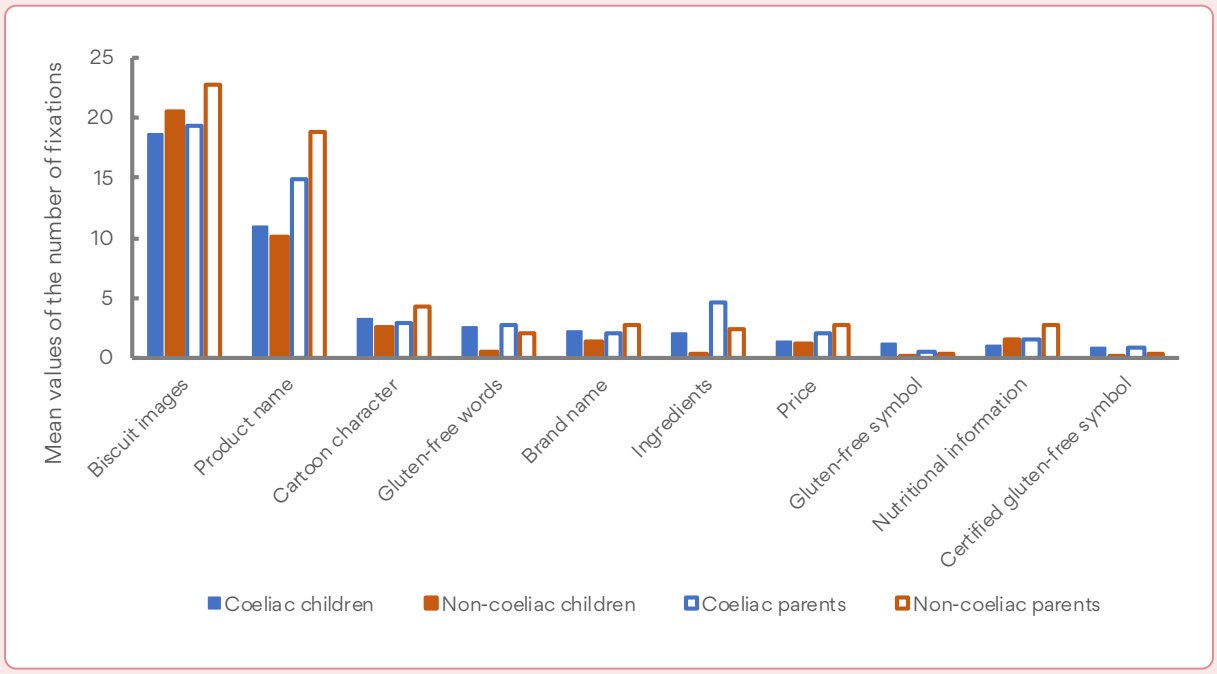
Why did participants choose a particular biscuit? Motivations from the laddering interview

After the purchasing activity, each participant was interviewed about the motives for their first and second option of biscuit choice during the purchasing activity, using the laddering technique. This interview started by asking each participant, "Why did you choose this biscuit?" followed by, "Why is that important to you?" and finally, "Why is the latter important to you?"

Results showed that all children looked for pleasure as the final value, but only coeliac children showed interest in the brand and in unknown products, as they would have liked to try them. Parents of both groups searched for pleasure and healthiness for their children, but they differed on the attributes linked to health, as parents seeking to help their children manage their condition also searched for a certification logo and a short ingredients list whereas other parents focused on low sugar or fat contents. It is worth noting that trust and

"Why did participants choose a particular biscuit?"

Figure 2. For each group of participants, mean values of the number of 'fixations' on each of biscuit' characteristics



economy were also relevant for parents of coeliac children.

Conclusions

Results from this study showed that coeliac children were more visually focused on gluten-free information (words and symbols) and the list of ingredients than non-coeliac children. Furthermore, they were more interested in the brand of products and in trying new products that they would not otherwise be able to eat.

Finally, regarding adults who took part in the study, parents of coeliac children chose biscuits with a gluten-free certification symbol and a short list of ingredients, as opposed to other parents, they did not mention low fat or sugar content.

The study shows how all adults wanted to make purchase choices based on health considerations, but those with children having a gluten intolerance were more focused on checking the ingredients and gluten free status of the product, as opposed to fat and sugar content. The data further suggests that, as coeliac children were interested in trying new products, (based on the study) there is potential for this market to grow.

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PLASMA-ASSISTED CL

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In the industrial food business the days of scrubbing down work surfaces by hand are all but gone. Today it is far more likely you that you would see high powered pressure washers among many other cleverly designed pieces of equipment. The term "*plasma*", however, is to the layman, probably the last word that you would be expected to hear in connection with cleaning. The term was, in fact, introduced into modern physics less than 100 years' ago to describe a "*fourth state*" of matter (the first three being solids, liquids and gas), in the form of several different types of ionised gasses, one being that which surrounds a lightning bolt.

There is, in fact, a perfectly acceptable argument that plasma could be named the first state of matter since the ordinary matter in our universe was once and still is in the form of plasma – similar to our sun, for example but solid, gas and liquid will usually prevail as terms we were brought up with.

OK, so that's the physics lesson over so: why do we need plasma and what does this have to do with the baking industry, you may ask? The apparent obscurity and potential lack of understanding of plasma could be the reason it has been under-used in the food business, however, this phenomenon is already in use and available today for highly effective surface cleaning.

So, what is plasma?
A little more physics I am afraid! In plain English, plasma is an ionised gas which means a collection of ions,

"Why do we need plasma and what does this have to do with the baking industry, you may ask?"

LEANING TECHNIQUE

electrons and high-energy species which, in simple terms, could be described as a high-energy gas, existing in disparate forms each suiting a different application. Generally speaking, for low-temperature applications like surface treatment or the cleaning of various surfaces, non-thermal plasmas would be the most suitable choice. Generating plasma in this form, is not energy demanding.

Armed with this knowledge, how can we put non-thermal plasma to good use and enhance the quality of surface cleaning in the bakery plant?

Status, environmental impact and regulations

Most countries in the world have similarly strict regulations related to hygiene in the food industry which today include HACCP quality assurance, regulating each segment of production, storage, processing and preparation of food products that usually require the companies producing or processing food, to define and document the food safety steps they are taking in order to preserve the welfare of consumers.

Nevertheless, each year, food corporations suffer the high cost of product retrieval and lost income related to contaminated food. This makes affordable cleaning, suitable disinfection and on-demand sterilisation of production installations and product distribution systems a potential gamechanger.

Existing cleaning methods and materials

The use of chemical agents still dominates both industrial and private sectors, despite the substantial effect that those chemicals can have on

waste water. Many components of wet cleaning chemicals (phosphonates, EDTA, optical brighteners and several types of additives) are only partially degradable with most conventional technologies. It is estimated that about 72% of waste water pollution originates from industry, closely followed by the agricultural sector and households[1]. According to the Bavarian State Office for the Environment, the annual amount of cleaning and washing chemicals discharged into the German waste water system alone is reported to be around 194,000 tons of surfactants, 32,000 tons of phosphates, followed by several tons of perfumes and optical brighteners; the environmental impact being substantial.

It is, therefore, important to continuously investigate, alternative and non-toxic cleaning processes for solid surfaces and waste water. One such technique is that of non-contact plasma-enhanced cleaning processes, which may result in a reduced environmental impact and partially replace chemical agents. Considering the technology's "cleaner" effect, it is interesting to note that the resistance and scepticism regarding the use of this relatively new technology in the food sector is still, quite significant.

Historically, the use of non-thermal plasma assisted technologies in the food sector was not only undesired but also forbidden for many years in several countries, particularly in Germany. Understandably, one major reason was the fear of the potential generation of unwanted or health threatening substances as by-products of plasma-food interactions.

Thankfully, intensification of research studies in plasma assisted cleaning technologies in the food industry, are showing positive results indicating that fears will soon be allayed.

The principle behind plasma assisted cleaning concepts

A specific study was designed and carried out, to evaluate the potential of a non-thermal, plasma-assisted, technology for the cleaning, decontamination and partial sterilisation of surfaces, tools and equipment parts, in the food industry. The main interest was to demonstrate and compare the effects of static and dynamic surface cleaning and to identify the most suitable techniques for further development. Added to this was the investigation of the sterilisation effect of atmospheric, non-thermal air-plasma jets in contact with the cleaned surfaces. For this purpose, we selected various food items; olive oil, cow's milk and eggs, to act as contaminates on a typical work surface.

Set up used for the static cleaning of the contaminated surfaces using low-pressure (vacuum), non-thermal plasma. Apart from the generation of air plasma within the glass cylinder as shown in the photo, tests were also conducted using most common technical gases like nitrogen, helium, carbon dioxide, etc. instead of air.

"Annual amount of cleaning and washing chemicals discharged into the German waste water system alone is reported to be around 194,000 tons of surfactants, 32,000 tons of phosphates."

Both static and dynamic cleaning set ups were used which were designed in a way that enabled sufficient surface/gas interface contact with non-thermal plasma electric discharges which initiated chemical reactions leading to the degradation of the contaminants on the surface and their subsequent removal.

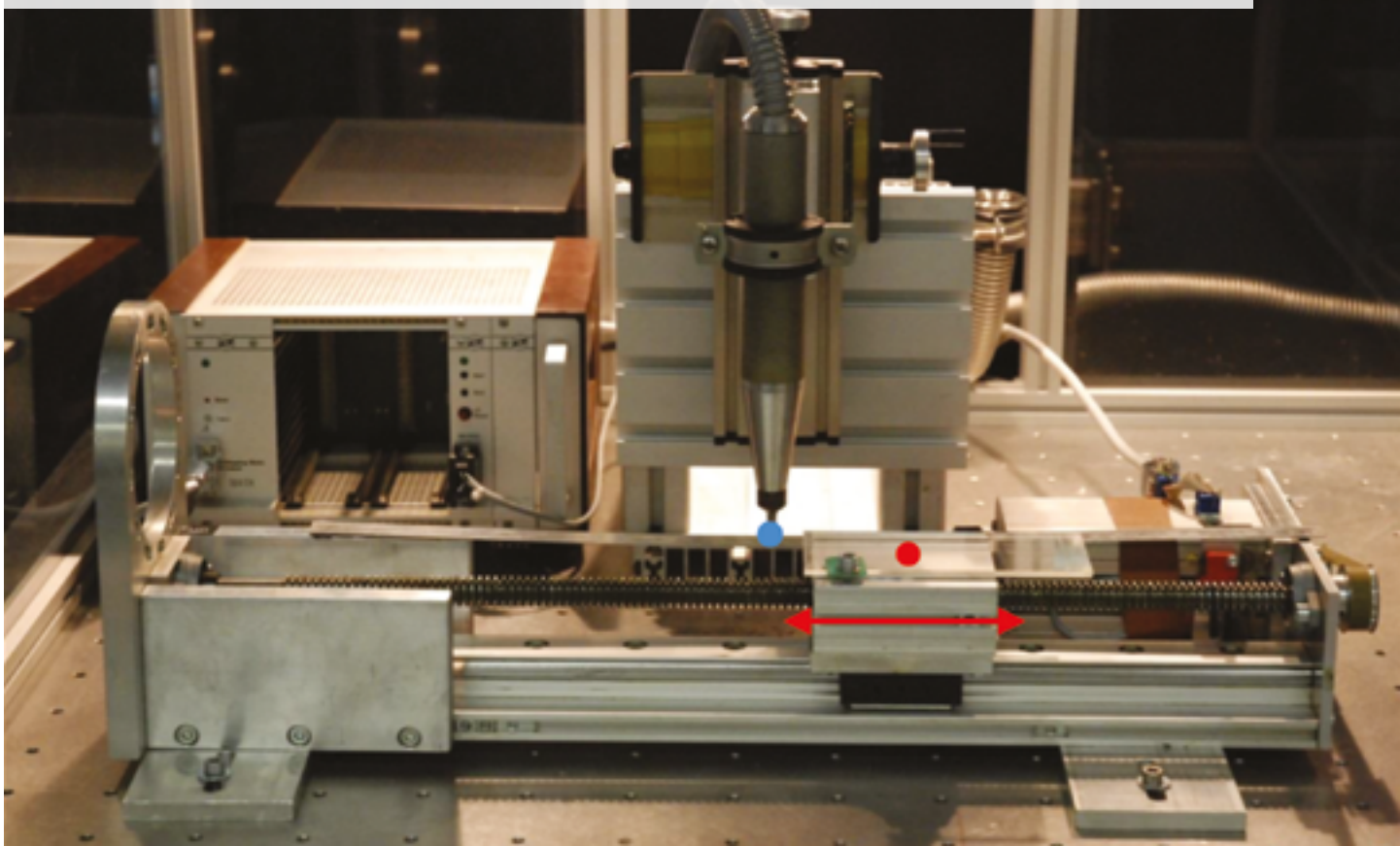
The main tools of plasma are radical chemical species such as OH, H, O, or NO, commonly formed in plasmas. These highly reactive species react with other plasma species, as well as with the targeted pollutants, destroying their molecular bonds as well as their bonds to the surface material.

Static surface cleaning

For static surface cleaning, plasmas were generated in a cylindrical glass test chamber. The plasma was "ignited" when the pressure in the chamber drops to 10-3 - 10-4 Pa. A high frequency - high voltage (HF-HV) generator was able to provide a total maximal power of 30W. Contaminated samples were placed on the plastic holder in the middle of the chamber between upper and lower electrodes. Tests were conducted for each selected contaminant and the test time varied from several minutes to up to one hour. In addition, effects of different electrode materials (Al, Fe and Cu), sizes (d=20 and 40 mm) and shapes (rods and discs electrodes), were also investigated.

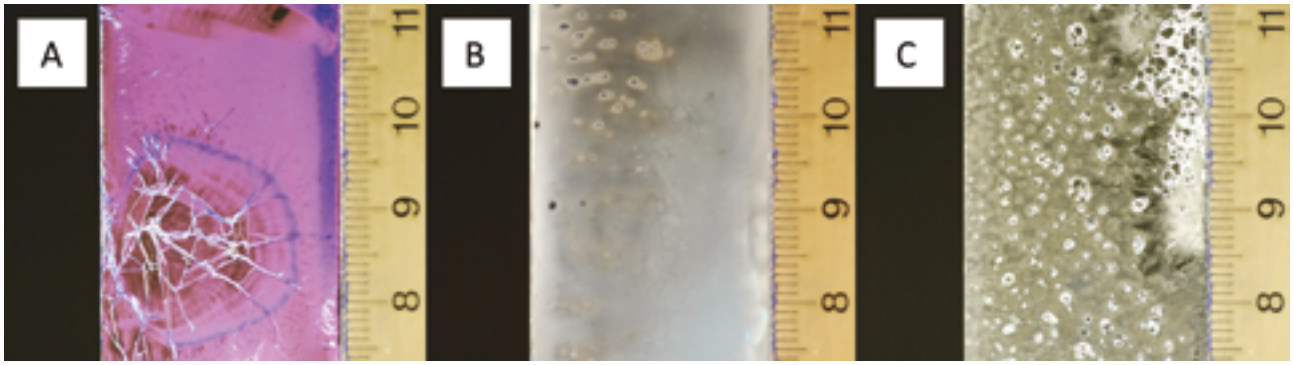
One advantage of low-pressure plasma generation is the relatively low electrical current needed to ionise or "ignite" the gas in the test chamber, however, this kind of treatment requires a vacuum and gas-sealed installation and cannot, therefore, be used *in situ*. The time required to remove contaminated parts that

In the set up used for the dynamic cleaning, contaminated glass plate (marked with the red dot) was moving under fixed plasma nozzle (blue dot). In industrial applications the nozzle could be easily moved over the surface instead.



needed to be cleaned, then reinstated, was lengthy and alongside the plasma chamber size, these were limiting factors, and therefore, major disadvantages for potential industrial use. These drawbacks can be avoided if the non-thermal plasma is generated outside the closed chamber at atmospheric pressure but at some cost, since a little more energy is required for the gas ionisation. This is somewhat mitigated since energy-demanding vacuum pumps would not be required but crucially, the process is not limited to the size of the plasma test chamber, so parts that need to be cleaned like cutting discs, knives, milling parts,

Samples contaminated with (A) olive oil, (B) milk and (C) eggs after 10 min. of exposure to the non-thermal plasma in vacuum chamber. Apart from the moderate changes of the surface of applied contaminant, there are no other effects that would indicate potential for the use of this method for cleaning. Prolonged test time, change in level of vacuum in the chamber or variation in the electrode material and shape did not result in any significant improvement.



"Each year, food corporations suffer the high cost of product retrieval and lost income related to contaminated food."

etc. can be done *in situ,* if the plasma jet can reach them.

Dynamic cleaning
In order to test dynamic cleaning of surfaces with non-thermal atmospheric plasma, a contaminated surface was moved under the plasma nozzle at different heights and speeds.

An atmospheric, non-thermal air-plasma generator was used at 10kV and 20kHz and was able to provide maximal power of 300W. Olive and sunflower oil were applied to the glass plate and used as test contaminants. Observation of the cleaning effects was carried out using two different imaging techniques: a) a colour indicator and b) an optical setup based on refracted light. The advantage of the latter being the absence of additives in the tested oil film.

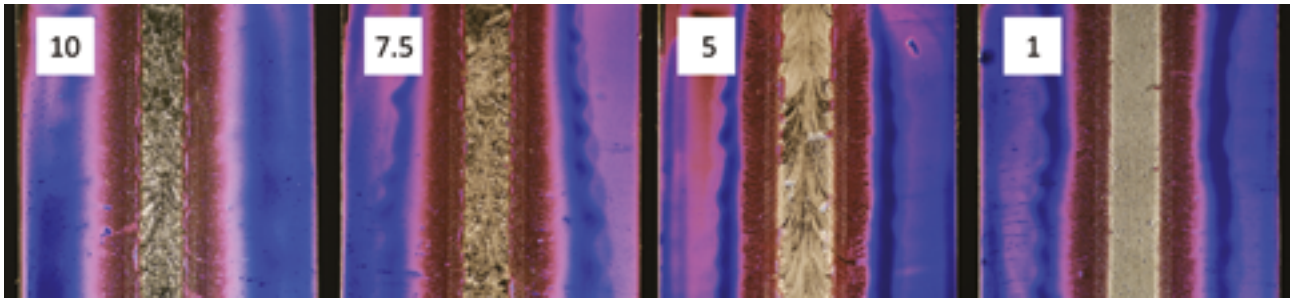
Extreme reactivity of the generated air plasma jet was known to have sterilisation effects if applied correctly, so in order to investigate this, so called "sterilisation tests" were designed. The ability of plasma to reduce biological contamination of the treated surfaces was investigated using glass plates, coated with a complex nutrient medium for the cultivation of bacteria. This medium consisted of 5 g/l yeast extract, 10 g/l of tryptone, 10g/l sodium chloride and 1g/l glucose, dissolved in 800ml of distilled water, autoclaved at 121°C. The prepared medium was inoculated with *E. coli* bacteria which was incubated for 24 hours in a heating cabinet at 30°C in order to reach maximum growth. After cultivation, the bacterial suspension was applied on a glass plates, previously cleaned with 70% ethanol and exposed to the Bunsen burner flame. Contaminated substrate was then applied on the whole surface of the sample plate and exposed to the plasma jet. The imprints of the contaminated glass plate and the glass plate after 5 seconds of atmospheric plasma jet treatment were made on the growth medium within Petri dishes.

Results of the tested plasma-assisted cleaning methods
Exposure of the samples contaminated with the olive oil, milk and eggs to the non-thermal air plasma within the vacuum chamber (static cleaning) showed quite poor effects. After 10 minutes of treatment, all test samples showed noticeable changes to the surfaces of applied contaminants and their relative separation from the glass surfaces. However, plasma in the low-pressure (vacuum) chamber was neither able to clean any of the contaminants formed on the glass surface nor was it able to have any significant cleaning effects even with an extremely prolonged exposure of more than an hour.

Conversely, results obtained with the dynamic cleaning setup based on the non-thermal, atmospheric air-plasma jet were quite promising.

The experiments with the plasma jet assisted dynamic cleaning showed the best results for the sample speeds, between 1 and 9mm/s and the distances between the plasma nozzle and the sample surface in the range of 3-10mm, as indicated in the graphs.

Test results of dynamic plasma assisted olive oil removal at different speeds of samples in the range from 1 to 10mm/s. White stripes left by the passing plasma jet indicate that the surface below the jet is oil-free. Coloured areas indicate the presence of oil film of different thicknesses.

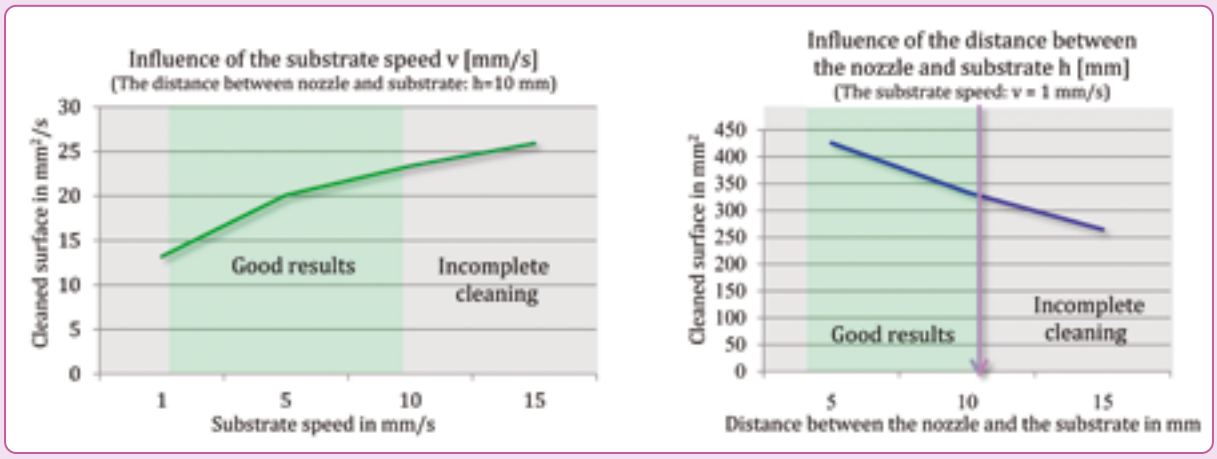


Higher speeds of the substrates or higher distances between plasma-jet and substrate lead to the reduction in the slow degradation of the quality of the cleaning process. Deeper investigation also showed that apart from the cleaning of the surfaces, the plasma jet had a significant sterilisation effect.

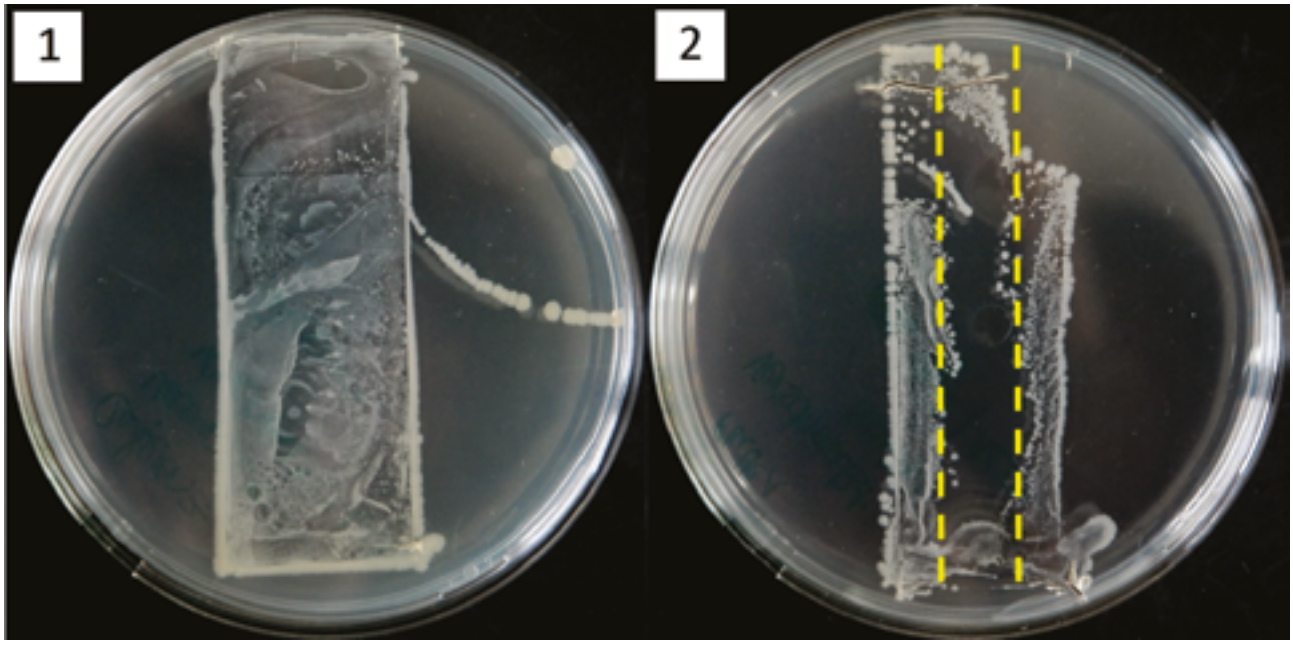
Results of the tests with imprints of the treated and untreated samples contaminated with E. coli bacteria on the substrates within the Petri dish, revealed another benefit of plasma treatment with more than 80% of the area exposed to the plasma jet being completely sterilised during the cleaning process.

Conclusion

The testing of plasma-assisted cleaning in the food industry, not only provided some solid answers, but also opened some new questions which warrant further investigation. The principle outcome of the experiments demonstrated the poor efficacy of low-temperature plasmas in a vacuum chamber.



Imprint of untreated sample (1) and sample after plasma jet treatment (2) on the substrates in the Petri dishes. Square (milky) areas indicate the presence of bacteria E. coli. Plasma treated area is marked with the dashed lines (2).



The tests on the dynamic systems, however, were far more promising, they being based on atmospheric, non-thermal plasma jets which showed efficiency in cleaning tested surfaces in a wide range of variable conditions. The best results were obtained with the cleaning of oily surfaces, whilst the removal of the egg material was quite poor.

Cleaning of the milk traces from was effective at lower sample speeds and distances between plasma jet nozzles and surfaces. Further optimisation would improve cleaning effects especially in the case of tailor-made systems designed for the removal of specifically targeted contaminants.

Apart from the positive results in the cleaning tests, plasma jets successfully sterilised surfaces and removed contaminants. Experiments with the contamination of the samples with *E. coli* bacteria showed that even at higher sample speeds, more than 80% of the treated surface was sterilised during the cleaning process.

Finally, with industrial waste disposal difficult, often expensive at the best of times and potentially environmentally damaging, a major benefit of using plasma technology is the total lack of waste created by by-products whether in liquid or solid form.

It also makes the technology potentially suitable for in-situ cleaning, which in some cases carried out without the need for process interruption or downtime, a huge boon, needless to say, for today's 24 hour production facility.

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COP26

Climate change and the difficulties facing globalised supply chains

Written by:

Ruth Luckins

The eventual outcomes of COP26 are important, but only address part of the complicated issue of sustainable food supply chains.

Agriculture and food supply chains are both causes and victims of the global climate and biodiversity crises: despite rapid advances in technology and demand for sustainability, they are still collectively the source of a third of greenhouse gas emissions worldwide[1] and often cause net negative impacts to ecosystems through land use change[2], while also being threatened by the effects – such as extreme weather and rising sea levels – of a rapidly changing climate.

The COP26 summit in Glasgow in November last year acknowledged all these issues, but there was no explicit focus on food systems in the main agenda and no headline-grabbing global commitments. However, several outcomes from COP26 will still have a direct effect on agriculture and supply chains.

Outcomes in the light of COP26

There is a growing awareness of the environmental impact of food, evident by the public protests that took place at COP26 and the very first UN Food Systems Summit – taking place just a month before. At organisational level, a recently published UN report has been critical of the environmental impact of agriculture on the planet.[3]

Yet despite this widespread recognition of challenges with the food supply chain, some momentum was lost in addressing food systems as a whole during COP26, with no specific inclusion of the topic in high profile agendas. Nonetheless, several sideline discussions and

commitments were made that will, in time, have a major impact on issues such as methane emissions and deforestation.

Methane

Methane is a much more powerful greenhouse gas than carbon dioxide, although it stays in the atmosphere for much less time. More than 100 countries, representing over half of global methane emissions, pledged to reduce their methane emissions by 30% by 2030, compared to 2020 levels[4] (China and India were notable exceptions).

Agricultural methane, mainly from livestock and rice paddies, accounts for 40% of human driven methane emissions, although the pledge text focused most heavily on the energy sector, which accounts for around 35%.[5]

Deforestation

Global deforestation is predominantly driven by clearing space for agriculture – soy and beef in the Amazon and palm oil in Indonesia and Southeast Asia being the biggest contributors. Forests act as important habitats and carbon sinks, as well as providing other 'services' such as reducing erosion and flooding from rainfall run-off. The Global Leaders' Declaration on Forests and Land Use

commits not only to halt, but also to reverse forest loss and degradation by 2030 and to facilitate trade and development policies that 'do not drive deforestation and land degradation.' A supporting Forest Finance Pledge promises to provide US$12 billion for forest-related climate finance by 2025.

Although a welcome change, there are some justified causes for scepticism around these commitments – the promise bears a striking similarity to an unfulfilled 2014 global deforestation pledge[6] and a tweet from Indonesia's environment and forestry minister soon after the announcement claimed that the pledge was 'clearly inappropriate and unfair.'[7]

Forestry, agriculture and commodity trade (FACT) statement
The FACT dialogue sets out a 'roadmap for action' to support sustainable trade between commodity producing and consuming countries while protecting critical ecosystems; objectives include trade and market development, traceability and transparency through to smallholder support.

Led by the UK and Indonesia, it was signed by 28 countries 'representing 75% of global trade in key commodities,' including the EU, US and Brazil. However, the dialogue is at best a work in progress of good intentions – actions are 'non-exhaustive, non-binding and do not apply in all circumstances to all countries.'[5]

Koronivia Joint Work on Agriculture
Away from the spotlight, an international group of delegates on behalf of the UN have been working to address agriculture through the lens of climate change since 2017, when the Koronivia Joint Work on Agriculture was established at COP23 in Fiji. The goal, being targeted through a series of international workshops, is to set out a roadmap for sustainable agriculture worldwide; a final text was expected by COP26. Although some consensus was reached, for example on soil and nutrient management, at the end of the summit there was still significant disagreement between parties, the new goal being to present a draft decision at COP27 next year.

These international level pledges are welcome signs of commitment to wide-reaching changes on a global scale, but they are voluntary commitments, which can and often do, fall short of targets. However, COP26 also provided a platform for non-governmental entities and organisations along supply chains to publish their own commitments. This business and private sector scale can have real influence and is where consumers and purchasers have power to hold suppliers to account.

95 high profile companies committed to becoming 'nature

Company	Headquarters	Main Commodities
ADM	UK	Grain, seed, fertiliser
Amaggi	Brazil	Soybean, corn, cotton
Bunge	USA	Oilseeds (soy, rapeseed, canola, sunflower), corn, wheat
Cargill	USA	Oilseeds (including biofuels and palm oil), vegetable oils, grains (wheat, corn, barley, sorghum)
COFCO	Switzerland	Grains, oilseeds, sugar (including for ethanol), coffee, cotton
Golden Agri-Resources	Singapore	Palm oil (plantations and processing)
JBS S.A	Brazil	Meat (beef, chicken, pork)
Louis Dreyfus Company	France	Animal feed, biofuels, pharmaceuticals, cotton, cereals, coffee, food oils, rice, sugar
Marfrig	Brazil	Beef
Olam International	Singapore	Cocoa, coffee, cotton, rice
Viterra	The Netherlands	Grains
Wilmar International	Singapore	Food oils (including palm oil)

positive' by 2030,[8] including 10 large-scale, global agriculture supply companies (see table) who have committed to phasing out forest loss associated with agriculture and trade in their supply chains. More details on how they intend to do this – whilst also increasing transparency on supply chains, scope 3 emissions, and improving livelihoods for farmers – is expected by COP27, in November 2022.[9]

In terms of demand, five of the UKs biggest supermarkets (Tesco, Sainsbury's, Co-op, M&S and Waitrose) announced at COP26 that they had signed the World Wildlife Fund's (WWF) Retailer's Commitment to Nature, which means they will be held to account by WWF on the actions they take to tackle key environmental issues including climate change, deforestation and the impacts of agriculture.[10]

So despite its lukewarm reception in the headlines, there is still real momentum in international and corporate spheres, as well as public demand, for dramatically reducing the harmful effects of agriculture and globalised food chains on the climate and environment.

Looking beyond environmental impacts

From a whole earth system perspective, agriculture is both absolutely key to support the world's growing population and also one of the main drivers behind environmental decline. The often cited planetary boundaries framework, originally proposed in 2009,[11] suggests that there are nine key areas where humans are applying pressure to the functioning of the earth system as a

whole – agriculture and food systems contribute to five of them: land system change, biochemical flows including phosphorus and nitrogen, biosphere integrity, freshwater use and climate change.

Yet, 65% of jobs and 29% of GDP in developing countries is reliant on agriculture, the produce of which is transported all over the globe.[12] Crops like soy, palm oil and sugar cane can only grow in tropical climates – which are mostly in developing countries – so whilst demand continues to grow and income is available for the produce, environmental damage will likely continue to take second place to economic development. The UN's overarching agenda to 2030, the Sustainable Development Goals, are somewhat conflicted on this in practice; there are significant and unresolved trade-offs between global scale social goals such as 'no poverty', 'zero hunger' and 'economic growth' and environmental goals addressing climate change and preserving life 'on land' and 'below water'.[13,14]

At the same time, agriculture systems worldwide are already bearing the brunt of extreme weather and climate

"From a whole earth system perspective, agriculture is both absolutely key to support the world's growing population and also one of the main drivers behind environmental decline."

hazards brought about by climate change. Typhoons and hurricanes are increasing in intensity (though not necessarily in frequency) thanks to the warming climate, as are intense rainfall and drought periods,[15] with their impact already being felt: just a few examples include frost and droughts in Brazil which have damaged everything from soybeans, corn and sugar to oranges and coffee trees resulting in reduced yields for up to two years; wildfires in Canada have impeded grain transport for weeks and flooding in Europe has led to a spike in fungal diseases in wheat.[16]

So, where does all this leave us? Firstly, sustainability, climate change and food supply chains are all incredibly complex, linked systems. To purchase green and sustainable produce in a globalised supply system is to navigate a maze of values, ensuring CO_2 emissions are as low as possible, human livelihoods and development are supported and security of supply can continue, as far as possible, in a rapidly changing climate. Secondly, momentum towards a world with more sustainable food systems is growing, with pressure from every level of the supply chain: international agreements and geopolitics, to agricultural commodity trading groups, to buyers, users, bakers and end consumers.

Agriculture, food supply and food systems, from farm to consumer, are undoubtedly under pressure and will continue to be so. But by maintaining an awareness of the linked issues, continuing vital work in innovation and technology, improving resilience and reliability of systems and holding companies, supermarkets and governments to account for their promises, everyone who forms a part in the chain can contribute towards creating a fairer and more sustainable system for the future.

About the author

Ruth Luckins is a Masters' student studying Climate Change (Environment, Science and Policy) at King's College London. She is interested in understanding the complexity of global systems in the context of addressing environmental and climate challenges.

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BREAD IN THE NEWS

Counting the cost and how to save money

Written by *Baking Europe's* sub-editor Richard Henderson in conjunction with Toine Timmermans

Toine Timmermans

Food Waste Free United Foundation

"Bread is a powerful link between our past and present food cultures" and although the way we get our news – recently featuring both bread and cultures – has changed, our regular buying of bread hasn't. This quote made by Dr Amaia Arranz-Otaegui of the University of Copenhagen in 2018 on finding bread dating back 14,000 years, may well have been the last time bread was a newsworthy item.

With possible supply shortages of wheat and rapidly rising energy costs having the potential to send the price of a loaf soaring, it is worth noting the flipside of this coin: the cost of waste. Even though we may have well-founded concerns about the cost of living, evidence from the Netherlands suggests we are still throwing money down the drain, or in this case, the bin. If we are anything like our European neighbours, we are probably binning a lot of bread: recent statistics estimate that in the Netherlands this could be as many as 800 hundred thousand loaves per day*.

So, in the interests of helping the planet and our fatiguing credit cards, we should perhaps take a look at some interesting bread related initiatives from the low country, as the land that started with the House of Orange has some green aspirations. Since 2018, action has been well underway to reduce food waste with the main contributor, bread, very much in focus. This staple accounts for the lion's share of food and

> "Evidence from the Netherlands suggests we are still throwing money down the drain, or in this case, the bin."

beverage products binned by households, followed by dairy products and vegetables*.

For the last four years the Food Waste Free United has led a campaign aimed at reducing household waste by half by 2030, using media and advertising in conjunction with the Netherlands Nutrition Centre. These two organisations hope to make consumers more aware of how they can reduce the amount of food they throw away. Research by the Centre confirms the groundswell of opinion regarding food waste: 80% of people are prepared to reduce waste, citing reasons such as saving money (61%), or on principle; as we should not waste food when there is famine (41%), or perhaps for reasons of sustainability, the majority, 67%, consider it 'simply unacceptable'. The Centre also researched why food is bought at the supermarket but not ultimately eaten. Purchasing too much of a perishable product or storing it incorrectly are two of the main reasons given by people as to why food waste ends up in the bin. Bread is so much a part of western diets it does not take a great leap to assume that similar amounts are being disposed of all across the continent.

Educating and, therefore, adapting consumer behaviour to minimise waste is taking place through the organisation of the annual, national Food Waste Free Week and other campaigns. It also includes a very useful and informative Food Waste Factsheet (see footnote for details). Along with demand, oversupply is also being considered and addressed. Food Waste Free United foundation has enlisted the help of 100 businesses and government organisations, amongst others, to help minimise the amount of bread left on the supermarket shelves at the end of the day. Toine Timmermans, director of the foundation believes this oversupply is the main issue to be addressed. He explains, "The best way is the prevention of

overproduction of (daily fresh) bread. New technologies offer more possibilities for the prevention of loss and waste. Thanks to the analytics and exchange of data within the supply chain, food businesses can further optimise their planning and forecasting and better manage product quality and shelf life. The rise of e-grocery also contributes, of course."

Check my flow

The Food Waste Free United foundation is aiming to meet the criteria set out by the United Nations Environment Programme. Sustainable Development Goal 12.3 states:

By 2030, halve per capita global food waste at the retail and consumer levels and reduce food losses along production and supply chains, including post-harvest losses."

In order to achieve this goal all organisations from farm to fork are being encouraged to take action. This is to be accomplished by setting targets and then monitoring them, by way of the old adage: 'what gets measured gets managed'. Data gathered can then be used to tackle waste hot spots ranging from on-farm food losses to household waste and everything in between.

In support of the data gathering process the Dutch bakery sector is lending support with a number of bakery associations and Wageningen University & Research, taking baseline measurements for annual monitoring and reporting 'residual flows' (waste resulting from bread production). Similarly, the Dutch Association for the Bakery and Confectionery Industry (VBZ) is developing a measurement tool for its members to monitor flows.

A large part of these residual flows of bread do go to the animal feed industry, but bread can also be turned into raw material for the food industry. For example, Wageningen University & Research has developed products from returned bread: bread pudding, gingerbread and sugar syrup.

One bakery ingredients company has carried out a pilot to produce these ingredients in an industrial bakery, aiming to develop the business case to attract investors. In the process, enzymes break down the returned bread into sugars that can again be used in the production of gingerbread or ordinary bread. Ultimately, they think 30% of the Dutch return bread could be processed.

The cold never bothered me anyway

As well as educating people about how to reduce waste and lowering bread supply, frozen bread may also help as a buffer when in-store bakery bread has sold out. This has the potential to have a great impact on waste in light of the figures below.

According to Food Waste Free United total bread waste can be broken down into these categories:

- 49% consumer waste

"A mind shift among consumers and supermarkets is necessary; we should accept mostly empty shelves at the end of the day."

- 37% returns (not sold)
- 10% production loss
- 2% raw materials loss
- 2% overproduction

Of all the bread purchased by supermarkets, 7.8%[1] returns (wasted or partly processed in feed). This makes bread (including bake-off bread and pastries) the category most wasted in supermarkets, but Toine Timmermans suggests there is a practical solution: "The Dutch supermarket is famous for its shelves full of daily fresh bread. A mind shift among consumers and supermarkets is necessary; we should accept mostly empty shelves at the end of the day. The sale of freshly frozen bread is an excellent option. About 70% of the Dutch population is already used to freezing bread at home to keep it fresh."

To illustrate this point a Dutch supermarket, Jumbo Verberne, in Wageningen, has carried out a pilot with 'freshly frozen bread', the aim being to prevent waste by reducing the stock of daily fresh bread at supermarkets. The idea is that if the fresh bread in supermarkets is sold out at the end of the day, there is still the freshly frozen bread available. This bread is frozen immediately after baking and sold from a freezer. As a result, supermarket bakeries no longer need to have fresh bread available all day. Thanks to the pilot, the supermarket can save an average of 87 loaves of bread per week. The pilot ensures a stable bread waste reduction of 66%[†]. After these results, more Dutch supermarkets are expected to start selling freshly frozen bread to consumers.

Timmermans acknowledges the drive towards reducing waste is already in evidence, "We see more and more attention to the prevention of bread waste in supermarkets. For example, some supermarkets sell 'Yesterday's Bread' or products that stay fresh for a longer time. At the end of the day, bakery products are discounted or sold through apps like Too Good To Go."

Need the info

With all these bread saving initiatives well established, statistics suggest that they are working. The amount of food waste shown by data shows an improved rate in the reduction in food waste since the campaign started, though even the researchers acknowledge the reasons for the improvement are not completely clear. Although waste per person declined, the total population increased and in conjunction with other data on demographics, these qualifying factors serve possibly to negate the data in relation to the food saving campaigns. Still, on the upside, the percentage of residual (non-recyclable) and fruit, vegetable and garden waste decreased during the period since the initiatives started. So, in short, the data suggests the campaign has helped to reduce waste, though it cannot wholly account for these savings. Regardless of the data, projects to raise awareness of the scale on which bread is wasted and educating consumers on how to prevent this waste is clearly a smart move in the drive towards more sustainable food supply chains. Alongside these modern initiatives, some old fashioned teaching can perhaps offer insight into the present, too, according to an old Dutch proverb, "If fools ate no bread, corn would be cheap". And as we all eat our toast digesting the news about the cost of corn, wheat and other commodities, you've got to admit, there's wisdom in that.

FOR MORE INFORMATION →

FOOD WASTE FREE UNITED

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NUDGING THE CONS

toward entomophagy in the bakery category

Written by:

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There are growing calls for consumers to start eating more insects, what is known as entomophagy.[1] Commercial insect production is associated with a much lower environmental footprint than traditional forms of farming animal protein. At the same time, however, while plant-based alternatives have increasingly started to make their way into the bakery category in recent years (e.g., see the extensive press coverage of the meteoric rise of Gregg's vegan sausage rolls, first launched in the UK as part of Veganuary in 2019),[2] there has, as yet, been far less progress as far as encouraging more entomophagy in the bakery category.

Insect flours would seem to be the most likely route – cricket flour and the like. Indeed, given that the insect matter is unlikely to be visible to the consumer, it should hopefully avoid the disgust response that eating whole insects can sometimes elicit.[3] However, it is worth noting that the price of cricket flour is substantially higher than for traditional grain flours (20-40 times higher depending on the season). What is more, cricket flour behaves much more like protein powder than traditional flour, so is currently no good for making muffins etc. – you are much more likely to see cricket-flour enhanced protein bars instead.[4]

In our own research at the Crossmodal Research Laboratory, we find that incorporating insect matter (such as male bee brood) into brownies or ice-cream (i.e., sweet

> "Anyone who likes peanut butter or jam on their bread is already eating insect matter."

UMER

treats) seems to be a very effective vehicle for getting people, especially children to try insect matter as part of their diet. However, one also needs to think carefully about how the insects in our food are described. On the one hand, there is the stealth approach, whereby we gradually increase the amount of insect matter that can be included in our foods before it has to be declared on the label. Note here how anyone who likes peanut butter

or jam on their bread is already eating insect matter regardless of whether they realize it or not. Currently, the guidelines state that the number of insect parts has to exceed a certain level (something like 35 insect parts per 100g) before it needs to be declared on the ingredient list. However, even when described explicitly, there are a number of different motivations (health-related, environmental, or social) for wanting to incorporate insect matter into one's diet, and it is important to recognize that not all may resonate equally with the consumer.[5]

Together with colleagues in Japan, we recently investigated the kinds of situations in which people reported that they would be more likely to try insect-based foods. Perhaps unsurprisingly, those we quizzed said that they would be more willing to try novel insect-based foods while out at the pub or bar with friends than, say, when on a romantic date.[6] Food festivals are another situation in which people appear more willing to try eating something different. From other research on diurnal differences in food consumption, I would also guess that people's willingness to engage in entomophagy would be higher in the evening than at breakfast-time.[7]

So, probably best hold off trying to perfect those cricket-flour based croissants for now. A more fruitful route to the incorporation of insect matter into the bakery category may come from substituting insect-based oils for vegetable oils when making cookies.[8] Recently, it has been shown that oils made from grasshoppers are richer in omega-3 fatty acids, flavonoids, and vitamin E than either olive or sesame oil.

Given how successful celebrity endorsement has been as a strategy to encourage consumption of certain products (just consider what George Clooney did for sales of Nespresso),[9] we have also been investigating whether celebrities might prove especially convincing when it comes to trying to nudge the consumer towards entomophagy.

Our participants reported that endorsement by actors/actresses would be more effective than endorsement by athletes, while endorsement by a musician was found to have no effect whatsoever.[10] It is an interesting question for future research as to whether the celebrity chef might be even more persuasive, given their well-documented success in encouraging sales of specific ingredients – see 'the Delia effect' and, more recently, 'the Heston effect'.[11]

However, if none of the above strategies should turn out to work in practice, there is always the option of feeding Fido insect-based pet food instead. This has been a rapidly growing area in recent years. Indeed, some commentators are confidently predicting a 50-fold increase in sales of insect-based pet foods within the next decade.[12]

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Biography: 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.

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