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healthy snack foods

how innovative frying technology can create healthier snacks with real consumer appeal

a tna white paper

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At leading processing equipment supplier, **tna**, Arnaud has more than 15 years of expertise in product development, quality assurance and research and development (R&D) for applications including beverages, dairy, fruit and vegetables, meat and functional ingredients. He is responsible for further developing **tna**'s equipment and processes to meet the needs of the company's growing customer base around the world. In addition, Arnaud also manages **tna**'s Florigo Food Technology Centre (FTC). Here, customers are able to test R&D, run simulations, host demonstrations and experience the latest in food engineering with on-site support.

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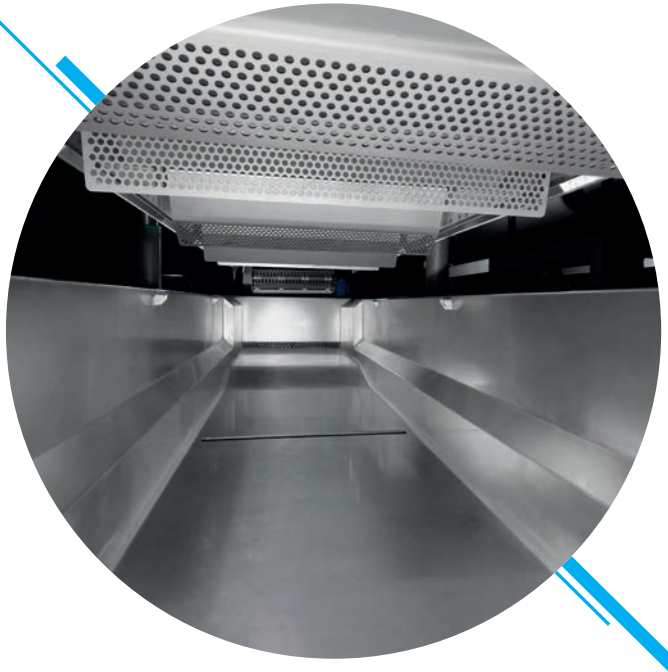
introduction

Frying is a popular cooking method worldwide with many cuisines across the world developing fried specialties for a wide range of applications. At the same time, consumer demand is gradually reshaping the way manufacturers are processing foodstuffs. With a growing trend towards health and wellness, consumers are more health-conscious and are consequently much more aware of what's in the food they eat, and how it is prepared or cooked.

As consumers seek healthier alternatives, fried food manufacturers are looking to create greater appeal by improving the perceived healthfulness of their products. Meanwhile, consumer preferences are also becoming much more discerning and refined. Not only do they look for healthier alternatives, they also want food that's readily available, tastes great and is appealing with a desirable colour and texture. This is leading to an increased level of innovation and new product development (NPD) across the food processing industry to address these demands and provide multiple benefits to consumers, both in terms of pre-processing solutions and frying innovations.



1 health & fried foods

During the frying process, fats and/or oils can be absorbed by food. As a result, food processes and nutrition labels are subject to an increasing number of regulatory policies. For example, in the US and other countries, fat content on nutrition labels is broken down into fat types including healthy fats like polyunsaturated and monounsaturated fats and less healthy fats, such as saturated and trans fats. The World Health Organisation (WHO) recommends reducing saturated fat intake to less than 10 per cent, and trans fats to less than 1 per cent, of total energy intake for adults. Thus promoting a move away from processed foods containing high amounts of these macronutrients.[1] As a result, manufacturers are relying on alternative methods to minimise the absorption of unhealthy fats into food during processing.

Starting with a complete review of their frying process, manufacturers can identify numerous opportunities to optimise their overall frying systems. This includes an evaluation of their oil management programme, regular maintenance of frying equipment – with emphasis placed on temperature controls, heating and heat transfer surfaces – and a comprehensive sanitation programme to ensure all food contact points are free of build-up. In addition, the quality of the oil itself is intrinsic to creating a healthier end product. The selection of a quality, high stability frying oil can help keep the formation of free fatty acids (FFAs) to a minimum, as well as providing additional benefits such as prolonged shelf life and superior taste.

Meanwhile, producers are also looking toward new ingredients as a possible solution to improving the healthfulness of their products. The snack category in particular, is ripe for innovation with manufacturers formulating with alternative ingredients such as ancient grains (e.g. Quinoa, Kamut, Oats), including flour and whole seeds. At the same time, the fruit and vegetable chip market is experiencing significant growth, with banana, kiwi and plantain chips becoming increasingly popular amongst consumers.

In addition to using healthier ingredients, manufacturers are also increasingly aware of acrylamide formation in fried foods, which has been shown to possess carcinogenic properties. This is especially important as chip-manufacturers are catering to health-conscious consumers who are, as mentioned, more and more aware of what they're eating.

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1 World Health Organisation – Healthy diet, September 2015. From: http://www.who.int/mediacentre/factsheets/fs394/en/

2 what is acrylamide?

Acrylamide is a chemical that can be formed in food via the reaction of asparagine (an amino acid) and reducing sugars (particularly glucose and fructose) at temperatures higher than 120 degrees Celsius during frying, baking, roasting, toasting and grilling. The amount of acrylamide formed depends on the final frying temperature, moisture content, cooking time and amount of asparagine and reducing sugars in the product. Potatoes and other root vegetables including sweet potatoes, beets and yams, for example, naturally contain both macronutrients. This means the formation of acrylamide is more common in chips produced using these types of raw materials. Other major contributing food groups include French fries, coffee, biscuits, pastries and bread.

Due to the health concerns associated with acrylamide, leading bodies such as the WHO and the Food and Agriculture Organisation (FAO) of the United Nations are paving the way to determine the risk of dietary acrylamide exposure, stating the levels of acrylamide in foods pose a 'major concern'.[2] Subsequently, major international efforts have been mounted to investigate the principal sources of dietary exposure, assess the associated health risks and develop preventative measures to reduce acrylamide levels, particularly in processed foods. In Europe new legislation which limits the amount of acrylamide in some foods came into force on April 11, 2018. The new EU regulation introduced new benchmark values for a wide range of products, including potato chips and French Fries, forcing manufacturers to closely examine and reduce acrylamide levels in their products.

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3 the rise of innovative processing techniques

A number of techniques has been developed to successfully reduce the levels of acrylamide in fried products, as well as create products lower in saturated fats. These include pre-processing techniques, such as blanching and pulsed electric field (PEF) technology, as well as innovative frying equipment, including multi-stage, vacuum and batch frying.

3.1 blanching & hot washing

Blanching is a processing technique that is often considered the most important tool for controlling reducing sugar levels in raw materials, and thus lowering the formation of acrylamide during frying. Also a traditional heat processing technique used in people's homes since the seventies, blanching has been improved and optimised over time for industrial and commercial purposes. As a result, it is a popular method for pre-processing products containing naturally high levels of sugar – to reduce sugar before frying. By placing the product in water of 80-90 degrees Celsius, the sugar dissolves and is removed from the cells. When blanching root vegetables, such as potatoes, beetroot, sweet potato and cassava for example, this can result in up to 50 percent reduction in sugar content, depending on slice thickness.[3] This allows manufacturers to offer consumers healthier and more appealing options.

2 Food and Agriculture Organization of the United Nations. World Health Organization. Summary report of the sixty-fourth meeting of the Joint FAO/WHO Expert Committee on Food Additives (JECFA).
3 **tna** Netherlands Manufacturing, Food Technology Centre (June 2014)

At the same time, manufacturers have optimised the blanching process over time to make way for new techniques, including hot washing, aiding snack producers to achieve the highest product quality. Usually, processing raw materials at temperatures higher than 90 degrees Celsius can result in pre-cooking. This can have a negative impact on the end product's textural stability, making it become soft or rubbery. For chip manufacturers looking to create a crispy, dry texture, this is not ideal. As such, producers increasingly use hot washing to reduce the sugar in chip slices. The slices are washed at lower temperatures (50-75 degrees Celsius) to prevent precooking and in doing so, firm up the plant fibres and cell structure to create a more stable product for frying.

In addition, processing at temperatures of 90 degrees Celsius or more can also reduce the mineral and vitamin content of the end product by removing important salts, vitamin C or vitamin A in carrots. This lowers the product's perceived healthfulness, while also resulting in a bland colour and taste that's not very appealing to consumers. Hot washing at a lower temperature can help overcome these issues. For instance, hot washing leafy green vegetables leads to the expulsion of air to give a brighter green colour for enhanced appearance and freezing capabilities. Meanwhile, as pre-processing technology continues to evolve, non-thermal technologies represent a novel area of food processing and are currently being explored on a global scale. Pulsed electric field (PEF) technology is one such example.

3.2 PEF technology

Unlike blanching, PEF technology is a relatively recent development which does not rely on heat treatment. A much gentler process, the technology works by using pulses of electricity to puncture cell membranes and allow fluid to exit. As a result, sugar and moisture are removed. This enhanced sugar extraction results in reduced acrylamide formation during cooking, while also allowing the use of all potato varieties, including those with high sugar levels / late season potatoes. Chip manufacturers are therefore able to decrease raw material costs while increasing product quality, as well as profitability. As a non-thermal processing technology, the product also remains raw throughout, maintaining the product's structure for improved texture and crispiness. At the same time, PEF treatment also improves cutting, thanks to a smoother surface, offering manufacturers the possibility to develop new cuts and shapes (e.g. thin lattice cuts). While this helps to create a crispier product, it also facilitates diverse ranges of healthier snacks, helping their products stand out on the supermarket shelves.

In addition to enhanced texture, PEF technology also aids the development of products with the visual appeal consumers expect. Colour, for example, is often determined by the amount of reducing sugars in the product. When processed at high temperatures, these sugars caramelise and burn, leading to browning. Their removal via PEF treatment reduces the effects of caramelisation, maintaining the original vibrant colour of the raw ingredients and optimising overall appearance.

PEF treatment also has a direct impact on oil uptake by food, including chips, thanks to improved cut smoothness. Conventional potato slices for example, usually exhibit a feathered edge made up of larger, and often broken cells that acts as an open door for oil absorption. In contrast, the perfectly smooth surface of a PEF-treated slice, with smaller, intact cells, inhibits excessive oil uptake while maintaining crispiness, with trials showing a reduced oil content of up to 25 per cent. This allows for the production of natural, low-fat snacks, as well as delivering the texture consumers desire.

At the same time, PEF technology can also lead to reduced frying time. Unlike conventional potato chips, the cells in PEF-treated chip slices are opened to allow the release of moisture prior to frying. In contrast, untreated slices possess a high moisture content, meaning that a longer frying time is required to evaporate the moisture from the chip. Trials demonstrate that PEF technology can lead to up to 25 per cent moisture reduction in potato chips, translating to a possible 25 per cent reduction in frying time, or alternatively, an increased production capacity of 25 per cent. This means manufacturers are better equipped to increase product throughput to meet growing demand for convenience foods.

3.3 multi-stage frying

Multi-stage frying (also referred to as two-stage frying) is increasingly used as an alternative method to straightforward atmospheric frying for the creation of healthier snack products. This tailor-made approach is broken down into two stages, the first of which is atmospheric pre-frying and the second, vacuum frying. During the initial stage, the product is fried at a high temperature (+/- 180 degrees celsius) to remove about 80 per cent of the moisture. The process is then completed at a lower temperature (approximately 120-130 degrees celsius) in a vacuum fryer. At this low temperature, acrylamide formation is very slow, almost unable to form, ensuring a safer and healthier end product.

Ideal for producing regular potato and vegetable chips, including organic varieties, this process offers the ability to create products with a natural taste and appearance, due to low cooking temperatures. Thanks to a much gentler process, the end product upholds the natural qualities of the raw material, including nutritional value and colour, without the need for additives or colourants. This is because the breaking down of important vitamins and minerals and natural colouring components is reduced. One such example is Vitamin A and beta carotene in carrots. At the same time, the process gives enough control to prevent discolouring such as browning or caramelisation. As a result, snacks are produced that have a recognisable taste and enhanced visual appeal to stand out in an increasingly competitive market. And for those who are looking to add more value to their products, rosemary extract is a common natural processing aid that, when added to oil, acts as an anti-oxidant to prevent degradation. In doing so, a natural declaration is possible while also adding natural flavouring to the end product.

Multi-stage frying is also compatible with a variety of oil types. A key ingredient in the processing of raw ingredients and most production lines, choosing the right oil can add considerable value to the end product. In the creation of healthier snacks, selecting a healthier oil has become a priority. From canola, sunflower and olive oil, to coconut and corn oil, manufacturers are inundated with choice. However, there are several considerations for those switching to healthier oils. Some types, for example, contain healthier compounds but are less stable at the heating stage, such as sunflower oil. Less stable means high levels of oil breakdown components when heated, thus reducing the nutritional properties of the end product. When an oil is less stable, shelf life stability also becomes a significant concern with some oils going rancid over time due to oxidation. Oils that are rich in essential fatty acids and other polyunsaturated fats are the most fragile. And because their shelf life is generally shorter compared to oils that contain saturated and monounsaturated fats, snacks processed in healthier oils can become less stable during their shelf life, resulting in an off-taste, appearance and smell. In addition, these are generally more costly due to their nutritional value and provenance.

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3.4 vacuum frying

Unlike multi-stage frying, vacuum frying continuously cooks products under low temperature and low pressure conditions, from start to finish. With this cutting-edge frying technology, the frying vessel is enclosed and pressure is reduced so that the boiling point of water is reduced to below 100 degrees Celsius. This means dehydration (the purpose of frying) can be driven by a lower oil temperature (+/- 90-130 degrees celsius). At these low temperatures, the degradation of the product's surface structure is reduced, lowering the amount of oil absorbed by up to three per cent with minimal impact on product quality.

Meanwhile, the use of high quality, healthier oil varieties is also possible. Oil oxidation is reduced due to lower frying temperatures and lack of oxygen present in the system, leading to a much longer shelf life and cost savings. As a result, manufacturers are able to create consumer appeal by improving the perceived healthfulness of their snack products.

In addition, vacuum frying systems are ideal for producing chips from fruit and vegetables that are high in natural sugars, such as parsnips, beets, carrots, apples, kiwifruit or mango, since temperature-related reactions, such as acrylamide formation, are slowed down significantly and in some cases do not occur. This is a particularly important development for potato and root chip manufacturers, since no matter what the reducing sugar level of the raw material, high quality end products are achievable. Potatoes containing 0.3 per cent or more sugar for example, are often considered low quality. However, with vacuum frying technology, the same quality end product can be achieved as using products with lower sugar content.

While vacuum frying enables producers to meet consumer trends for healthier and low fat products, it is also allows them to develop goods with positive organoleptic properties, such as taste, texture and appearance. At high frying temperatures, sugars present in food caramelise leading to browning, and influencing the colour of the final product. At low temperatures however, the colour of the raw ingredient is much easier to maintain since caramelisation does not occur. In comparison to atmospheric frying, for example, processors have more control over the product's final colour.

This gentle processing technique also helps to deliver improved texture and crispiness in snack products. At higher temperatures, fast heat transfer occurs, whereby moisture evaporates quickly damaging cell structure. This results in a hard texture. Reducing the pressure of a frying system therefore lowers the temperature required for evaporation to take place. Consequently, the moisture gently evaporates from the product, producing the characteristic crispy texture for which chips are known. Furthermore, because the movement of moisture is less forceful during vacuum frying, products are able to retain more of the flavour inherent in the raw ingredients.

3.5 batch frying

Batch frying is an additional technology which is currently being explored to produce healthier snack products, as manufacturers look to optimise the atmospheric batch frying process. In particular, they have been experimenting with fruit and vegetables containing high levels of starch and/or reducing sugars. These include beets, green plantain, ripe plantain, banana, cassava, sweet potato, carrots and bread fruit. In comparison to continuous frying processes where products are cooked at high temperatures (approximately 180 degrees Celsius) for a short amount of time, batch frying involves cooking at 140 degrees Celsius for a longer length of time. At these lower temperatures, acrylamide formation is reduced, creating safer fruit and vegetable chips.

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As well as helping to produce safer products, batch frying is also proven to reduce fat content via reduced oil uptake during processing. The starting temperature of a batch fryer is usually approximately 140-160 degrees celsius, depending on the raw materials. As the product is added to the fryer, the overall temperature of the oil kettle drops approximately 30 degrees celsius (= ΔT) . The extra low temperature helps to seal the outside cells of the product, preventing oil absorption. This avoids excessive oil uptake, allowing manufacturers to market their products as 'reduced fat'. Furthermore, in the final minute of frying, the temperature in the kettle returns to its starting temperature which is usually the point in the process which determines colour formation. In potato chip production for instance, this end temperature is ideal for colour formation and caramelisation, for a product that is typically light in colour, without browning.

Texture is the most important factor in batch frying. For all types of chips, a very crunchy texture, described as 'glassy' or 'hard', can be achieved, which is often associated with high quality, premium-style products. Again, this is a result of the overall temperature drop in the fryer when the product is added to the kettle. As it is fried off, moisture within the slices starts to boil. The boiling effect opens up the structure within the cells, and as the product dries toward the end of the process, the structure strengthens and becomes hard. This structure creates the well-known 'crunch' or 'bite' consumers associate with batch-fried chips.

3.6 continuous frying

In the continuous frying process, the product is continuously fed into the fryer. The infeed temperature is stabilised at around 180 degrees Celsius through hot oil injections over the length of the entire frying pan, while heat exchangers ensure that the temperature is regulated and kept at a constant level throughout the frying process. As a result, the frying time is significantly shorter than in batch type systems, allowing for higher throughput levels.

In many conventional frying systems, when the oil flow increases in the fryer so does the turbulence, which can cause the oil to spin in one place at the infeed of the frying kettle, resulting in unevenly fried potato slices and therefore an increase in the level of acrylamide and rejects. However, continuous fryers that are equipped with a special oil flow control technology allow manufacturers to accurately control the dwell time of the chips in the hot oil to ensure that each chip is fried evenly and to perfection. For example, using an innovative oil inlet design at the beginning of the fryer can change the fluid dynamics within the kettle and increase oil flow speed to produce a more streamlined laminar flow over the full width and length of the fryer pan. It therefore effectively minimises the occurrence of turbulence by removing 99 per cent of cyclone dead spots at the beginning of the fryer. This prevents debris from settling and ensures that potato slices don't absorb or carry any excess oil. As a result, each potato chip is evenly fried, lowering the level of acrylamide and reducing the number of rejects for enhanced product quality and increased yield.

At the same time, precise temperature control is essential for the production of healthy chips. Continuous fryers with double heat exchangers can accurately control the oil temperature, making it possible to lower the temperature right at the end of the frying process by up to 30 degrees and therefore reducing the formation of acrylamide significantly.

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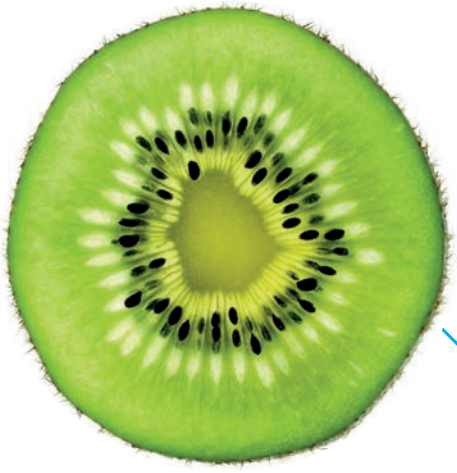

summary

While frying remains a popular cooking method around the world, consumers continue to seek healthier products that are readily available, but still exhibit a desirable taste, texture and appearance. As such, snack food manufacturers in particular, are seeking new ways to differentiate their product offering by improving the healthfulness of their products. Whether it's via the incorporation of new ingredients or advanced pre-processing and frying techniques, there is a multitude of options available for creating healthier convenience foods. As such, it is important to work with a supplier that has the technological expertise and know-how to find the right solutions to fit individual production requirements. Partnering a leading processing solutions supplier, such as tna, gives food manufacturers the ability to do just that and ultimately stand out from the competition in this dynamic and constantly evolving market..

If you would like to find out how **tna**'s innovative processing technology can help you create healthier snack products, please contact us at info**@tna**solutions.com

About **tna**

tna is a leading global supplier of integrated food packaging and processing solutions with over 14,000 systems installed across more than 120 countries. The company provides a comprehensive range of products including materials handling, processing, coating, distribution, seasoning, weighing, packaging, cooling, freezing, metal detection, verification and end of line solutions. **tna** also offers a variety of production line controls integration & SCADA reporting options, project management and training. **tna**'s unique combination of innovative technologies, extensive project management experience and 24 /7 global support ensures customers achieve faster, more reliable and flexible food products at the lowest cost of ownership.

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