The frying experience:

Exploring the evolution from conventional to air frying technology

By Jorge Luis Alonso G, information consultant specialising in potatoes

In restaurants, at home and in the food industry, frying is one of the most common methods of food preparation. It is a technique used all over the world, based on the dehydration of food immersed in hot oil. The speed and ease of preparation, the low price and the aggregation of desirable food properties contribute to its use. These include colour, texture and flavour. All of these positive attributes are the result of the physical and chemical changes that occur during the frying process.

Fried food and human health

Few studies have focused on the biological consequences of consuming oil-fried foods in humans. However, polar compounds found in fried foods have been linked to endothelial dysfunction and high blood pressure, which can lead to chronic diseases, especially cardiovascular disease. People who eat fried foods are also more likely to develop obesity and intestinal disorders.

Despite the restrictions, fried products are trendy, consumed in and out of the home, and found as fast food in many restaurants. But because of the risks of a high-fat diet, modern day consumers are increasingly looking for more nutritious and safer food alternatives. Reducing the oil content in fried foods has become a necessity.

Several alternatives are available to replace the traditional frying process with systems that provide similar characteristics of fried foods, but with higher nutritional quality and ease of use.

Based on this idea, air fryer technology has appeared on the market. These devices use hot air combined with high-speed air circulation to heat food from all sides at the same time, without adding oil. The proposal is to obtain fried foods with low amounts of fat. Its acceptance depends on the sensory characteristics of the final product, which should be close to those of the conventional frying process.

In 2019, a team of researchers based in Sao Paulo, Brazil published a review on the changes that occur in foods that are subjected to conventional and air frying, comparing the pros and cons of these processes. Their paper 'Frying Process: From Conventional to Air Frying Technology' was published in the journal *Food Reviews International* and can be accessed here: *www.tandfonline.com/doi/abs/10.1080/87559129.2019.1600541*.

Significance of the frying process

Frying is an efficient method due to its speed, unique sensory properties, and preservative effect. The moisture content after frying determines the shelf life of fried foods: the more dehydrated by frying, the longer the shelf life. For example, potato chips or corn chips have a shelf life of up to 12 months at room temperature.

There are two main techniques of commercial frying that differ in the method of heat transfer: surface frying and deep frying:

- **Surface frying:** A thin layer of oil transfers heat from the hot surface of the pan to the food. The product has a different brown colour and prevents product standardisation.
- **Deep frying:** Heat transfer is a combination of convection in the hot oil and conduction into the food. All surfaces receive similar heat treatment, resulting in uniform colour and appearance.

Similarly, the frying process can be continuous or discontinuous. The continuous process is used by the industrial market for frying extruded snacks, fried pasta, and pre-cooked and fried potatoes. The discontinuous one is used by the institutional market, including fast food chains, restaurants and pastry shops.

What happens at high temperatures?

Placing food in hot oil raises the surface temperature and evaporates water; the surface then begins to dry. The evaporation layer moves into

the food, forming a porous surface crust. Its rapid formation is beneficial because it retains moisture in the food and limits the rate of heat transfer to the interior. Economic considerations and product requirements determine the temperature used for frying. For instance, high temperatures (180 to 200°C) reduce processing times and increase production rates.

Fears about the health effects of consuming trans fats have led industries to substitute raw materials such as frying oils. But the benefits of replacing saturated fats with unsaturated fats come with many drawbacks. For example, the high unsaturated fatty acid content leads to instability at high temperatures and increased susceptibility to oxidation, rancidity and off-flavours. Also, the sensory characteristics of some of these oils can affect the taste of the food or result in reduced crispness, palatability and flavour.

During the heating of the oil, some reactions produce many degradation compounds. With the continuity of the reactions, the functional, sensorial and nutritional change leads to a low-quality product. For these reasons frequent oil changes are necessary, thus increasing costs. Equally important is contamination from degraded oil and acrolein, an oil degradation product characterised by the formation of a bluish mist.

Reactions and changes in food

Certain chemical reactions cause a reduction in quality or deterioration during the frying procedure. Frying exposes oil and fat to three factors that can degrade quality and alter composition:

- Moisture from the food (which causes hydrolytic changes).
- Oxygen in the air (which enters the oil through the surface of the cooking vessel, causing oxidative changes).
- High temperature.

Colour is an important quality attribute that influences consumer food choices. and air frying requires more time to achieve the characteristic colour of food fried in oil.

There are many changes in the properties of oils and foods, such as sensory (flavour, aroma, texture and colour), nutritional, functional and toxicity qualities. The most observed physical changes in oils are viscosity increase, colour change, and foaming.

For foods subjected to such a process, the possible results can be both desirable and undesirable. For example, the colour presented by the potato after frying implies its acceptability. This visual characteristic is influenced by oil type, oil age and thermal history, oil/product interfacial tension, temperature, cooking time, and sample size.

Sugar content also affects the colour of fried potatoes because the hydrolysis of sucrose by the enzyme invertase is the primary source of glucose and fructose-reducing sugars, which are precursors to the Maillard reaction. This reaction is a non-enzymatic reaction between free amino acids and reducing sugars at high temperatures. It produces dark pigments and toxic products such as acrylamide.

High levels of reduced sugars in tubers result in poor-quality potato chips.

The production of the texture in fried foods is a result of changes in proteins, fats, and polymeric carbohydrates. Specifically, changes in protein quality occur through the Maillard reaction with the amino acids in the crust.

Different methods of frying

The effect of frying on the nutritional value of food varies depending on the type of process used. High temperatures of the oils result in a rapid formation of the crust, which seals the surface of the food, causing a reduction in changes within the interior and significant retention of nutrients.

Researchers have attributed changes in fried food quality to starch gelatinisation reactions, protein denaturation, caramelisation, enzyme inactivation, and fat absorption.

The oxidation of fat-soluble vitamins in the oil contributes to a loss of nutritional value, as retinol, carotenoids, and tocopherols are destroyed, which alters the taste and colour of the oil. However, tocopherols undergo preferential oxidation, resulting in an antioxidant effect on the oil.

This effect is particularly important since most frying oils have a vegetable origin and contain a large proportion of unsaturated fats that tend to oxidise.

As the frying process alters the chemical nature of the heated oil, generating toxic compounds, there is a concern for the safety of the consumer and the possible consequences for the human organism.

Air frying technology

The air frying process is an alternative to conventional frying that addresses its drawbacks. It uses hot air to cook a variety of fried foods instead of dipping them in hot oil. In this process, a fine mist of oil droplets in the hot air comes into direct contact with the food, resulting in even and efficient heat transfer that minimises quality variations. The food is dehydrated during the process and gradually develops a crust-like deep frying.

Air frying technology was first introduced in European markets, where it was well received, and later introduced worldwide. This patented technology cooks food while maintaining a pleasant taste and reducing the fat content by up to 80% compared to deep frying.

But it is important to consider other potential benefits and drawbacks of this technology, including changes in food characteristics and comparisons with traditional frying methods.

Air frying versus deep frying

When air frying was compared with deep frying by some authors, it was

found that the samples of French fries absorbed about ten times more oil in the hot oil frying process during the same frying time. In frozen potatoes, the oil content was changed from the original content in deep frying, while the oil concentration was reduced to half of the original content in air frying.

However, this reduction in oil content resulted in the formation of a less uniform crust that was less resistant to water loss and affected the sensory characteristics of the final product.

The air frying process showed a similar moisture concentration compared to deep frying, but water and volume losses were higher. The formation of a crust in the frying process limited the water loss.

Changes in oil content were observed in both processes when samples of French fries were blanched or frozen. A study found that air frying could achieve the characteristic colour of deep frying. Deep frying results in products with lower fat content and similar moisture and colour compared to air frying.

One of the relative disadvantages of air frying is that it requires a longer cooking time than frying, which may not be ideal for people who have busy lifestyles and need to prepare meals.

Nevertheless, the air frying process can be used to produce low-fat products, although the products may have different sensory characteristics such as taste, colour, odour, appearance, hardness, crispiness, crunchiness and oiliness.

The crispness factor

On the other hand, the air frying technology did not show significant differences in sensory attributes such as taste, appearance, odour, and acceptability when compared to oil frying. In fact, air frying was preferred for crispness, firmness, oiliness, and colour.

In addition, potato strips prepared by the air frying process showed superiority in attributes such as hardness, crispiness, and oiliness when compared to traditional fried potatoes, which may be attributed to the lower oil uptake compared to deep frying.

Studies using scanning electron microscopy (SEM) and differential scanning calorimetry (DSC) have shown that the main difference between products subjected to air frying and immersion frying is the greater extent of starch gelatinisation that occurs in traditional frying, resulting in a dry and thick crust.

The thin, homogeneous and smooth crust obtained by air frying is due to the slow evaporation of water from the surface of the product, which prevents intense local evaporation of water and hinders starch gelatinisation.

Colour, speed and water content

However, the central region of air-fried products is harder compared to those from immersion frying due to the lower degree of starch gelatinisation at lower temperatures. Some authors studied oil absorption during immersion frying and found that it occurs mostly toward the end of the process, resulting from the condensation of water vapor in the product caused by a drop in temperature below the boiling point.

In air frying, higher water losses during the process were not compensated by significant oil absorption, resulting in higher mass losses.

Colour is an important quality attribute that influences consumer food choices, and air frying requires more time to achieve the characteristic colour of food fried in oil.

Although the boiling point of water is reached almost linearly with time in both air frying and oil frying, it is reached faster in deep frying than in air frying. Beyond this point, air frying maintains a constant temperature while deep frying shows a significant temperature increase above 100°C.

The researchers agree that air frying has several advantages over conventional fryings, such as being a practical alternative for obtaining healthier fried foods due to reduced fat content, lipid degradation and oxidation.

It also has environmental benefits such as reduced oil consumption and wastewater emissions. According to one study, air fryers offer more significant energy savings than others, which translates into a 70% savings.

A final word

The current shift in society's eating habits deserves attention and requires constant monitoring, particularly from the food industry. Although there is no evidence to suggest the discontinuation of frying in meal preparation, air frying technology is recommended due to its ability to reduce the oil content in foods. It has been proposed that the use of air frying equipment may become a trend in the coming years for snack factories, fast food chains, restaurants, and homes.

This alternative offers several advantages, including decreased costs of vegetable oils, reduced environmental pollution, and energy conservation, while also appealing to consumers who seek healthier dietary options, which can ultimately benefit businesses.

Despite its benefits, more attention should be given to studying air frying technology and its mechanisms of action on food components and properties, as well as its effects on human health.

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