Vacuum Frying Technology-New Technique for Healthy Fried Foods

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For decades, consumers have desired deep-fat fried products because of their unique flavor- texture combination, ranging from potato chips, French fries, doughnuts, extruded snacks, fish sticks, and the traditional-fried chicken products. Frying is one of the oldest and most popular cooking methods in existence. Frying in vacuum condition is a new technology that can be used to improve the quality of fried foods because it is working in low temperatures and use the minimum oxygen content. Deep-fat frying is a method to produce dried food where an edible fat heated above the boiling of water serves as the heat transfer medium, fat also migrates into the food, providing nutrients and flavour (Fan *et al*., 2005). These conditions lead to high heat transfer rates, rapid cooking, browning, texture, and flavour development. Therefore, deep-fat frying is often selected as a method for creating unique flavors, colors, and textures in processed fried foods. However, surface darkening and many adverse reactions take place during deep-fat frying because of high temperature. Due to the pressure lowering, the boiling points both of the fat and moisture in the foods are lowered. Vacuum frying is an alternative technique to improve the quality of dehydrated food (Song *et al*., 2007).

Advantages of vacuum frying

Vacuum fried products has low moisture content (<6%) and low water activity (aW<0.3) (Wongsuwan and Laosuksuwan, 2006). The absence of air during frying may inhibit oxidation including lipid oxidation, enzymatic browning; therefore, the color and nutrients of fried samples can be largely preserved (Tarzi *et al*., 2011). The products are crispy and retain original colour, taste and odour as of the natural foods. Vacuum frying have some advantages, first it can reduce oil content in the fried product. Second it can preserve natural color and flavors of the product depend to the low temperature and oxygen content during frying process and third it has less adverse effect on oil quality. Likewise vacuum frying is beneficial to some fruits or vegetables with intense odour such as durian. Vacuum fried durian is less objectionable and more convenient to carry when compared with fresh durian. Vacuum frying can be used to fry high sugar fruits and fresh vegetable in order to produce various kinds of snacks. Sugar is burnt before water is removed from the fruits. The products still have high moisture content.

Disadvantages of vacuum frying

In financial terms, investment cost of vacuum frying process is much higher than that of deep frying. This is because vacuum frying technique is basically designed for large scale industry. There is a lack of design of vacuum fryer for small scale production. Small scale producers such as grower group, small community enterprise, and cooperatives find it hard to afford vacuum frying machines and equipment without financial support from Government. (Inprasit, 2003).

Application of vacuum frying and their benefits in processing of food products

Vacuum frying reduces oil uptake and improves the quality parameters of carrot crisps and plantain chips

Oil uptake is one of the most important quality parameters of fried foods, but this is incompatible with recent consumer trends towards healthier food and low fat products (Bouchon and Pyle, 2004). The consumption of oil and saturated fat in particular is related to significant health problems, including coronary heart disease, cancer, diabetes, and hypertension (Saguy and Dana, 2003). Other undesirable effects derived from the high temperatures involved in the frying process and exposure to oxygen are the degradation of important nutritional compounds and the generation of toxic molecules in the foodstuff or the frying oil itself (Fillion and Henry, 1998). The low pressure may allow air to diffuse faster into the porous structure, obstructing oil passage and leading to lower oil absorption than is observed in atmospheric frying. Sudden increase in the surrounding pressure, which may force the vapours & oil inside of the pores (Garayo & Moreira, 2002). Vacuum fried carrot slices absorbed 47% and 50.5% (d.b.) less oil than atmospheric fried ones when using thermal driving forces of 60^{o} C and 80 ^{o}C, respectively (V. Dueik*et al*., 2010). In plantain chips vacuum frying is a promising technique that can be used to reduce oil content at 3 minutes and 5 minutes for (ΔT=50, 60, 70) were the lowest (10.39 and 12.35, 10.64 and 17.39, 12.86, 13.4) %, respectively compared to atmospheric with (14.48 and 14.55, 15.4 and 15.74, 14.81 and 15.76) % high oil content and the colour parameter Lightness, redness and yellowness were best preserved for vacuum frying at ΔT=50 (Olakunle, 2014).

The effect of a de-oiling mechanism on the production of high quality vacuum fried potato chips

In the case of vacuum frying, this problem is exacerbated by the pressurization step, which causes a quick increase in pressure in the pore space thus forcing most of the surface oil into the product pore spaces. Therefore, for vacuum frying, a de-oiling mechanism is required to reduce the excessive oil absorption at the surface of the product. Potato slices were fried for 360 s in a lab-scale vacuum fryer (P < 1.33 kPa) at 120, 130, and 140 ^{o} C. A centrifuging system (750 rpm for 40 s) was used before pressurizing the vessel. Samples fried at 120 ^{o}C for 360 s (non-centrifuged) had a final oil content of 0.43 g/g product compared to 0.097 g/g product for the centrifuged ones (Rosana *et al*., 2009).

Effect of vacuum frying on the oxidative stability of oils

During frying, oil or fat is exposed to air, water, and heat. Therefore, thermal, oxidative, and hydrolytic decomposition of the oil may take place. Fats and oils are oxidized to form hydroperoxides, the primary oxidation products. These peroxides are extremely unstable and decompose via fission, dehydration, and formation of free radicals to form a variety of chemical products, such as alcohols, aldehydes, ketones, acids, dimers, trimers, polymers, and cyclic compounds. palm oil, lard, and soybean oil were fried under vacuum at 105°C for 20 min each hour in an 8-h shift. Results showed that palm oil and lard possess greater thermal stability than soybean oil (Shyi-Liang *et al*., 1998).

Vacuum frying preserves carotenoid content carrot crisps

The most abundant carotenoid found in fresh and fried carrot samples was trans β-carotene, which represents about 60% of total carotenoid content. The second-most abundant was trans α-carotene, which accounts for nearly 40%. These results are in agreement with the literature that has reported that trans β-carotene content ranges from 60% to 80%, whereas trans α-carotene content ranges from 10% to 40% (Chen *et al*., 1995). The processing of foods may cause major carotenoid degradation due to the isomerisation of trans-carotenoids, which represent almost 100% of total carotenoid content in raw carrots (Kopas-Lane and Warthesen, 1995). Trans–cisisomerisation affects pro-vitamin A activity, bioavailability, and the antioxidant capacity of carotenoids. Also, there is some evidence that all-trans-isomers are absorbed preferentially by humans as compared to cis isomers in the case of β-carotene. Vacuum fried crisps (driving force of 60^{o}C) preserve around 90% of trans α-carotene and 86% trans β-carotene, which leads to the preservation of the colour of raw carrots (Dueik *et al*., 2010).

Reduction of Acrylamide Formation in Potato Chips by Low-temperature Vacuum Frying

Recent studies (Tareke *et al*., 2000) reported that acrylamide, a genotoxic carcinogen, is formed during high-temperature processes, including frying. Acrylamide is formed primarily in carbohydrate-rich food cooked at high temperature. Among the different food products analyzed, the highest levels of acrylamide have been found in French fries, potato chips, and other fried, deep-fat fried, or oven-cooked potato products, together with some crisp bread, biscuits, crackers, and breakfast cereals (Tareke *et al*., 2000). Mottran and others (2002) reported that asparagine, a major amino acid in potatoes and cereals, is the crucial component in the production of acrylamide by the Maillard reaction pathway. Compared with traditional frying (atmospheric conditions), vacuum frying reduced acrylamide formation in potato chips dramatically by about 94%. Vacuum frying potato slices at 118 °C produced potato chips with low acrylamide content and desirable yellow golden color and texture attributes compared with those fried in the traditional fryer (Granda *et al*., 2004).

Comparative study of physical and sensory properties of pre-treated potato slices during vacuum and atmospheric frying

Potato slices of Desire´e and Panda varieties (diameter: 30mm; thickness: 3mm) were pre-treated in the following ways: (i) control or unblanched slices without predrying; (ii) blanched slices in hot water at 85°C for 3.5 min and air-dried at 60°C until a final moisture content of 0.6 kg water/kg dry solid; (iii) control slices soaked in a 3.5 kg/m^3 sodium metabisulphite solution at 20 °C for 3 min and pH adjusted to 3. Pre-treated slices were fried at 120 and 140 °C C under vacuum conditions (5.37 kPa, absolute pressure) and under atmospheric pressure until they reached a final moisture content of 1.8 kg water/100 kg (wet basis). Sensory evaluation confirmed these results, the colour of the potato slices fried at atmospheric conditions was evaluated as ''darker'' and ''worst'' than the potato slices fried at vacuum conditions. Texture quality was significantly ''better'' for vacuum fried chips and flavor quality and overall quality were improved when vacuum frying was used instead of atmospheric frying. A great improvement on colour parameters was obtained using sulphited potato slices instead of the other pre-treatments (Troncoso *et al*., 2009).

Conclusion

- There is tremendous scope for vacuum frying in Indian snack Industry.
- Seems to be an ideal alternative for fried snack products– environmental safe and high quality end product.
- More research is needed on the sensory impact of foods treated with vacuum frying technology.
- By using the other seasonal indigenous fruits we can explore the market further and provide the consumers with newer products.
- Research is needed to use vacuum frying technology for Traditional Indian Dairy Products like Khoa/ mawa based *Gulabjamun* and its impact on physical and sensory characteristics.

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