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Review Article

A Short Review on Vacuum Frying-A Promising Technology for Healthier and Better Fried Foods

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Abstract

Vacuum frying is developed method of conventional frying method under low pressure and low temperature, which improve the quality attributes of fried food products. This technology is gaining popularity in modern days due to recent research findings establishing the relationship between conventional fried food consumption and human health problems. Vacuum frying on the other hand proves to be a better and healthier alternative option than conventional frying. Objective of this review paper is to provide the reader, comprehensive information about the basics of vacuum frying technology, recent research updates and possible research gaps. India being the leader of fruits and vegetable production, fails in adequate food processing/preservation due to inadequate storage infrastructure, incurring huge post-harvest losses every year. Vacuum frying process may be adopted as a method of food preservation or new product development, by overcoming the research gaps and proper commercialization of the technology in small as well as in large industrial scales.

Keywords: Vacuum Frying; Principle; Applications; Advantages

Introduction

Frying is an age-old method for food processing, where lipids are used as heat transfer medium that comes in direct contact to the food [1]. There are different methods of frying like pan frying, stir frying and deep frying. Deep frying has now-a-days become an industrial operation, i.e. potato chips processing. During frying, both fats and oils are invariably used as heating medium at high temperature of 160 - 180°C or even more as per frying requirement [2].

When the process of frying is visualized superficially, then one would feel that, frying phenomenon taking place in the product, that is dipped in hot oil or fat subjected at high temperature. But closer observation of the process would reveal that a number of phenomena occurs during frying process as listed below:

- **Cooking:** This is the main reason of frying, caused by various thermal inducted chemical reactions like starch gelatinization, protein denaturation, Malliard reaction, caramelization along with number of compounds synthesis responsible for characteristic fried sensory qualities.
- **Dehydration:** During frying operation, where the temperature of the oil is always maintained much above 100°C, causing rapid removal of water in form of steam from the frying food product.
- **Oil uptake by the fried product:** This may be termed as desirable or undesirable change that the lipid content of fried products was found high due to uptake of fats from the frying media, i.e. oil/ fat.
- **Crust formation:** Causing changes in texture of the products along with structural changes.

These are the phenomenal changes that occur during the frying process. Earlier it was thought that oil uptake takes place during the frying process (in the beginning phase of frying), as the moisture from the capillaries evaporates out of the food. But now recent studies have shown that major amount of oil uptake takes place from the adhering surface oil, in the cooling phase, when the fried product have been taken out from the oil by suction action [3-5]. Conventionally fried product may contain as high as 40% oil, which affects the product characteristics [6] and also the high lipid content of the fired product is becoming a source of health concern of the daily consumers [2]. High lipid containing foods had been related with a number of human health related problems and even early deaths. Some of the diseases occurring in human due to consumption of high lipid content foods are provided below:

- Obesity and development of other chronic diseases [7,8].
- Cancer risk (National Cancer Institute, under NIH-U.S. Department of Health and Human Services) [7].

- Acrylamide- Compound commonly found in baked and fried products had been classified as "probable human carcinogen" compound by World Health Organization (WHO) [9].
- Risk of prostate cancer [10].
- Greater risk of Type-2 Diabetes [11].
- Increased chances of coronary artery disease /heart disease [11].

Keeping all these immediate threats in consideration, the diet and health conscious consumers are changing their eating trends from high lipid containing foods towards nutritious foods. Even the food processing industries are looking towards better processing methods that would reduce the harmful effects of food processing and make foods safer and better for human consumption, without compromising the taste of the food. One such processing method is vacuum frying, which may be considered as an alternate method of conventional frying [12].

Vacuum Frying Technology-Principle

Vacuum frying is similar to conventional frying, but it is carried out under low pressure below 50 Torr (6.65 kPa). In comparison to conventional frying, vacuum frying is considered a much better option since vacuum fried product contains much lesser oil and lower acrylamide content, with similar texture/colour and better organoleptic and nutritional properties, in comparison to conventionally fried food. It is an efficient method to produce fruit and vegetable snacks with the necessary degree of dehydration without excessive darkening or scorching [13-15,17].

Vacuum frying is achievable at lower temperature than conventional frying, therefore vacuum-fried products have better nutritional quality (due to retention of essential phytochemicals and essential nutrition), enhanced colour (due to lesser oxidation) and oil degradation is much lesser than normal frying.

Vacuum fried products contains lesser oil content, but this is not only the single health benefit of vacuum fried products. Lower operating temperature during vacuum frying, reduce 94% of acrylamide formation in potato chips. Acrylamide is recognised as a potential carcinogenic compound found in fried snacks, which is formed by the Maillard reaction [16-18].

Vacuum frying have been adopted for processing (i.e. frying) different foods, but mostly for fruits and vegetables. Factors affecting the final vacuum fried products are frying time-temperature combination which determines the final acceptable physical attributes. For frying, the oil temperature may be increased to frying temperature by using gas, steam or electricity. As discussed earlier, during frying, there would be significant removal of moisture in form of steam along with other volatiles, which may be trapped using a condenser. Low pressure is created during vacuum frying with the help of either liquid ring or oil sealed vacuum pumps. After frying, the excess oil present in the product may be removed by centrifugation. A separate de-oiling operation needs to be done, to remove extra surface absorbed oil, during the last stage of vacuum frying operation [19-21].

Some steps during vacuum frying and their justification

- **Blanching:** This step is done to prevent enzymatic activity before vacuum frying by either steam blanching and hot water blanching.
- **Freezing:** Contribute to form a porous sponge-like structure and improve the texture of the vacuum-fried food.
- **Vacuum Frying:** Already discussed.
- **Defatting:** Vacuum fried products, after frying are separated from excess oil by lifting up the product or subjecting it to centrifugal separator, with or without breaking the vacuum.
- **Packaging:** Similar to conventional fried products, the vacuum fried products are also having tendency of rancidity. PET (Polyethylene tetraphthalate) or Aluminium film laminate (AFL) with nitrogen gas filling may be used for packaging vacuum fried products [19,22].

Recent Work Done in Vacuum Frying

Low pressure "vacuum frying and oil separating" technology was patented by Yang (1989) to eliminate the disadvantages of conventional atmospheric frying method which produced greasy fries and oxidation of frying oil in short time [23].

Many works have been done till date in vacuum frying technology, where it was found that in recent years, vacuum-frying process is successfully adopted for processing different fruits (i.e. apple, pineapple, grapes, banana, guava, mango, peach, etc.) and vegetables (i.e. sweet potato, potato, pumpkin, carrots, etc.) into fried chips like products and fried fishes and shellfishes (i.e. octopus and cattle fish) [24].

Vacuum frying has good potential to be applied for development of snacks from fruits and vegetables, with health benefits and better qualities. As discussed in previous section that before vacuum frying there is need for some pre-treatments, i.e. blanching, osmotic pre-treatment, freezing, pre-drying etc. These pre-treatments play role in moisture removal kinetics, product yield, final product moisture content, fat content of the product and fat distribution in the final product. Initial plant set up investment for vacuum frying is much higher compared to convention deep frying plant. Another challenge is the availability of vacuum fryer for small capacity operation, though large capacity plants are available. This becomes a challenge for the small level players, like entrepreneurs and small-scale industries to adopt vacuum frying process. Research is needed to use vacuum frying technology for Traditional Indian Dairy Products (TIDP) like khoa/mawa based Gulab jamun and its impact on physical and sensory characteristics [25,26].

Akinpelu., *et al*. (2014) worked on vacuum frying process optimization for plantain chips with desired quality attributes, where optimum processing conditions for vacuum frying of plantain chips were 133°C at 9.91 cm Hg and 6 min for frying temperature, vacuum pressure, and frying time [27].

Further Moreira (2014) stated that better understanding about the structural changes taking place during the process, would help to develop final product with better quality. Number of studies have been conducted on changes taking place and kinetic studies on moisture losses, oil absorption during vacuum frying and its comparison to conventional frying process and product quality. Limited studies were found on process simulation of vacuum frying by fundamental modelling [18].

Conclusion

Vacuum frying technology have added advantages over conventional frying. Vacuum frying process is achievable at lower temperature than conventional frying and minimizes formation of acrylamide, which is a harmful thermal reaction product. Reduced lipid content of the final product, because of lower oil intake during vacuum frying process and higher rate of moisture evaporation are other advantages of the process, including improvement in sensorial and textural properties of the vacuum fried products.

Limitation for vacuum frying process is the initial investment for vacuum frying processing is quite higher as compared to conventional frying process. Beside this, small-scale vacuum processing plant is not available, which is a big hurdle faced by entrepreneurs, small organization etc. Higher costs of machineries for vacuum processing are difficult to afford. Moreover, studies needed to be done about application of vacuum frying on traditional food products. Changes of sensorial impact during vacuum frying needs to be established in comparison with conventional frying. Beside this there is scope of improvement in fundamental process modelling of vacuum frying including the steps and changes taking place during the process.

In future, the vacuum fried products would be a suitable alternate for conventional fried products with better nutritional and sensorial properties. It would be more preferred over the fried products due to low oil and acrylamide content. With time, consumers are becoming more and more health and diet conscious and this tread promises a bright future of vacuum processing as a novel method of food processing.

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Conflict of Interest

Authors have no conflict of interest to declare.

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