ISSN: 0975 -8542

Journal of Global Pharma Technology

Available Online at: www.jgpt.co.in

RESEARCH ARTICLE

Effect of Frying And Storage on the Quality and Shelf Life of Fried Sweet Potato (*Ipomoea Batatas*) Chip

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Abstract

Sweet potato is the seventh most important crop in terms of global production. Sweet potatoes are rich in antioxidants, such as phytophenolics and carotenoids which also provide distinct flesh colours. The high perishability of sweet potato roots during storage remains a major constraint. It is widely cooked by deep frying and consumed in forms of French fries and chips. Consumers are increasingly health conscious and trends are moving toward foods with low oil content. This research has been focused on different parameters of drying for minimum oil absorption and sensory palatability while maintaining the most phytochemical components such as total phenolic, total flavonoid and carotenoid; extending product shelf life during packaging and preservation. Results revealed that frying 2.0 cm of sweet potato chip in soybean oil heating at 150^oC in 2 minutes was appropriated. Fried sweet potato chip could be preserved for 12 weeks under vaccum at 4^oC. Moisture and oil content, as well as colour and texture are important quality attributes of fried sweet potato products. Frying of sweet potato bars is carried out to convert the roots to value added products. Frying method brings out unique flavor and texture to the products that improve their overall acceptability.

Keywords: *Sweet potato chip, Frying, Shelf life, Carotenoid, Flavonoid, Vaccum.*

Introduction

Sweet potato (*Ipomoea batatas*) is a dicotyledonous species belonging to the morning glory family, Convolvulaceae. It is an herbaceous perennial vine with alternate heart-shaped, lobed leaves and medium-sized flowers. The root is edible and is often long and tapered. The skin may be red, purple, or brown and white in color. The flesh may be white, yellow, orange or purple. The leaves and shoots are eaten as vegetables [1].

It is a perennial crop which serves as one of the major sources of food, animal feed and industrial raw materials. It has a significant contribution as energy supplement and phytochemical source of nutrition. It is widely cultivated in the tropics, subtropics and even in some temperate zones of the developing world[2]. Orange-fleshed sweet potato contains high percentage of carbohydrate, reducing sugar and phenolics; while white-fleshed sweet potato has high levels of total protein, flavonoids, anthocyanins, and carotenoids [3]. *Ipomoea batatas* contain high levels of polyphenols such as anthocyanins and phenolic acids and are a good source of vitamins A, B and C, iron, calcium and phosphorus [4].

Ipomoea batatas has been reported to possess anti oxidant, anti-diabetic, wound healing, anti-ulcer, antibacterial, and anti-mutagenic activities [5]. It is also used as an immune booster and for relief of gastrointestinal and upper respiratory symptoms. The boiled roots of Ipomoea batatas are believed to relieve diarrhea, and crushed leaves are used to treat acne and boils [4]. During storage, the roots are very perishable because they contain high moisture content (60-75%) hence low mechanical strength as well as high susceptible to microbial decay. They have high respiratory rate and the resultant heat production softens the textures which make them susceptible to damage. Postharvest quality deterioration emanates from respiration, weight loss, microbial attack, weevil damage and sprouting [6]. The frying process results in unique flavor, colour and texture attributes which are the main drivers of consumer acceptability of the products [7, 8].

Consumer preference for low-fat food products has been the driving force for the food industry to produce good quality fried potatoes with reduced oil uptake [9]. Too much oil content in a fried product endows it with an oily taste while too little oil content deprives it of the typical appealing taste and odour of the fried product. Oil uptake in fried potato products has generally been related to the amount of moisture, starch and dry matter content of the raw potato as well as temperature of the frying oil [10, 11]. There were some studies mentioned to sweet potato (*Ipomoea batatas*) frying. Physicochemical and sensory characteristics of sweet potato chips undergoing different cooking methods was examined [12].

Effect of pre- drying and frying kinetics of sweet potato (*Ipomoea batatas* L.) chips was observed [13]. Quality changes in different cultivars of sweet potato during deep-fat frying were monitored [14]. Sweet potato chips were produced by vacuum-belt drying and compared to deep-fat fried (DFF) chips. Two thicknesses (0.8 and 1.5 mm) and four drying temperatures (100, 120, 140C and mixed temperature [T-mix] = 100/120/140C) were investigated [15]. A research was to determine the effect of some pretreatments on moisture, vitamin C content and color and oil absorption of fried sweet potato chips [16]. Investigation was carried out to study kinetics of moisture loss, oil uptake, lightness and textural changes during deep fat frying of sweet potato *(Ipomoea batatas L.)* chip[17]. Effect of frying temperature and time on composition and sensory quality of sweet potato crisps was observed[18]. It is important to investigate frying conditions for use by potential small scale processors while ensuring acceptable quality of sweet potato chip.

Hence, the objective of this study was to determine the effect of frying temperature and time, thickness of sweet potato chip on the composition and sensory properties of sweet potato chip during frying, packaging and storage.

Material & Method

Material

Sweet potato (*Ipomoea batatas)* was collected in Bac Lieu province, Vietnam. After harvesting, it must be temporarily preserved in dry cool place. In laboratory, it was thoroughly washed to remove dirt and foreign matter. Sweet potato would be chopped into bars with different thickness depth.

The oil tank was filled with 10 liters of soybean oil and preheated. Once the oil temperature reached the target value, the frying basket with 1kg of chopped sweet potato chip was placed in the frying vessel and the lid was closed. After frying, the fried sweet potato chips were removed from the basket, allowed to cool to ambient temperature for 20 minutes, and then be packed in metalized polyethylene pouches.

Figure 1: Sweet potato (*Ipomoea batatas)*

Research Method

Effect of Frying Temperature and Time on Physicochemical and Sensory Properties of Fried Sweet Potato Chip

Four levels of frying temperature (°C) namely (i) 140°C in 4 minutes (ii) 145°C in 3 minutes (iii) 150°C in 2 minutes (iv) 155°C in 1 minute were carried out. The best frying temperature and time was selected based on the values of moisture (g/kg) and oil (g/kg) content; total phenolic (mg GAE/ g), total flavonoid (mg QE/g), carotenoid (mg BCE/g); sensory score of fried sweet potato chip.

Effect of Thickness of Sweet Potato Chip on Physicochemical and Sensory Properties of Fried Sweet Potato Chip

Thickness of sweet potato chip was examined in four different size levels (1.0 cm, 1.5 cm, 2.0 cm, 3.0 cm). The best thickness of sweet potato chip was selected based on the values of moisture (g/kg) and oil (g/kg) content; total phenolic (mg GAE/ g), total flavonoid (mg QE/g), carotenoid (mg BCE/g); sensory score of fried sweet potato chip.

Effect of Packaging and Storage Temperature on Shelf Life of Fried Sweet Potato Chip

Fried sweet potato chip would be packed by two different bags (zipper and vaccum) and stored in two different temperatures (4°C and 28°C) during 12 weeks of storage. Shelf life of fried sweet potato chip was based on the changes in thiobarbituric acid (TBARs) (mg malonaldehyde/ kg).

Physico-chemical and Statistical Analysis

Moisture (g/kg) content of fried sweet potato chips was determined in triplicate according to the AOAC method (AOAC, 2000) using a hot air oven. Oil (g/kg) content of fried sweet potato chips was determined in triplicate by petroleum ether extraction using the Soxhlet extraction unit. Total phenolic (mg GAE/ g) content was determined by the method based on oxidation–reduction reaction by Folin–Ciocalteu reagent using gallic acid as a standard. Total flavonoids (mg QE/g) content was determined by colorimetric method [19]. Total carotenoid (mg BCE/g) contents were determined by the modified method of Koala et al [20]. Sensory score was based on 9-point hedonic scale. The thiobarbituric acid (TBARs) (mg malonaldehyde/ kg) of fried sweet potato chips was determined in triplicate by a distillation method [21]. Data were statistically summarized by Statgraphics Centurion XVI.

Result & Discussion

Effect of Frying Temperature and Time on Physicochemical and Sensory Properties of Fried Sweet Potato Chip

Sweet potato roots are a good source of carbohydrates, an excellent source of beta-carotene, a very good source of vitamin C and manganese, and a good source of copper, dietary fibre, vitamin B6, potassium and iron [22]. The roots and skin contain high levels of polyphenols such as anthocyanins and phenolic acids [23].

Table 1: Effect of frying temperature and time on physicochemical and sensory properties of fried sweet potato chip

Frying	Moisture (g/kg)	Oil (g/ kg)	Total phenolic (mg GAE/ g)	Total flavonoid (mg QE/g)	Carotenoid (mg BCE/g)	Sensory score
140°C in 4 minutes	0.51±0.02^{a}	1.63±0.01^{a}	1.57±0.01^{b}	0.71±0.01^{d}	0.045±0.00^{b}	7.45±0.02^{ab}
145°C in 3 minutes	0.50±0.00^{ab}	1.61±0.01^{ab}	1.59±0.03^{ab}	0.73±0.02^{b}	0.047±0.00^{ab}	7.61±0.01^{ab}
150°C in 2 minutes	**0.49±0.01^{ab}**	**1.60±0.01^{ab}**	**1.62**±0.01^{a}	**0.75**±0.00^{a}	**0.050**±0.00^{a}	**7.73±0.03^{a}**
155°C in 1 minute	0.47±0.02^{b}	1.59±0.01^{b}	1.58±0.00^{ab}	0.72±0.01^{c}	0.046±0.00^{ab}	7.17±0.00^{b}

Data are expressed as mean ± SD values (n = 3). Mean value with different superscript in each column differs signifcantly ($p<0.05$)

From table 1, the sweet potato chip should be fried at 150oC in 2 minutes to achieve the best physicochemical and sensory properties of finished products. Frying is a simultaneous heat and mass transfer process where moisture leaves the food in the form of vapour bubbles, while oil is absorbed simultaneously. The frying process results in unique flavor, color and texture attributes which are the main drivers of consumer acceptability of the products. Moisture and oil content, as well as colour and texture are important quality attributes of fried sweet potato. Effects of frying temperature (90, 95°C), frying time (50, 60 minutes) and cycles (8 frying cycles; 4 continuous cycles/day) on physicochemical properties of vacuum fried pineapple (cv. *Phulae*) chips were studied.

Frying temperature signifcantly (p≤0.05) affected moisture content while frying time affected color of pineapple chips. The optimal vacuum frying condition was at 60 mmHg (abs) and 95°C for 50 minutes. Signifcant changes in the chip color increased with increasing frying cycles [24]. Physicochemical and sensory characteristics of sweet potato chips undergoing different cooking methods was examined. Dven-baked and air fried chips presented the lowest fat and moisture content, which increased their shelf life. Furthermore, all deep-fried sweet potato chips showed the best sensory acceptance and purchase intent by tasters [12].

Effect of pre- drying and frying kinetics of sweet potato (*Ipomoea batatas* L.) chips was observed. Based on sensory rating chips dried at 200% db at a temperature of 60ºC and fried at 170ºC for 180 s resulted best quality of chips [13]. Several studies have shown that higher initial moisture content in the food material resulted in increased fat uptake in the finished products.

This is because in deep frying, high temperatures (between 160 and 180ºC) cause water to evaporate from the food towards the surrounding oil, while the food absorbs oil to replace part of the evaporated water.25 A research was to determine the effect of some pretreatments on moisture, vitamin **C** content and color and oil absorption of fried sweet potato chips. Prior frying, sweet potato slices were pre-dried and blanched and pre-dried or treated with 0.1% citric acid solution and pre-dried. The pre-drying treatments were carried out at 70°C for 0, 30, 50 and 70 min. The mean of moisture content of the dried, blanched and citric acid treated chips were in the range of 1.38-1.91, 1.04-1.41 and 1.35-1.88%, respectively. While, the fat content in the same samples ranged between 12.57-14.23, 14.09-17.92 and 12.31-14.54%, respectively. Vitamin C content in fried sweet potato chips pre-dried only, blanched and pre-dried and citric acid treated and pre-dried ranged between 17.43-40.50, 9.23-29.23 and 19.87-44.93 mg 100 g-1, respectively. The samples pre-dried only gave darker chips compared to that blanched and pre-dried or citric acid treated and pre-dried.

Fried sweet potato chips treated with citric acid and pre-dried for 50 min had the best sensory scores for all sensory quality attributes.15 Effect of frying temperature and time on composition and sensory quality of sweet potato crisps was observed. Crisps produced at 150-170 ºC at 3-8 min were generally acceptable, although the sample with the highest overall acceptability score was produced at 170 °C/8 min [18].

Effect of Thickness of Sweet Potato Chip on Physicochemical and Sensory Properties of Fried Sweet Potato Chip

Mode of heat transfer from medium into the food pieces during initial heat-up stage was convection, subsequently when the temperature inside reached the boiling point, moisture started to evaporate during the constant rate stage. The last stage was falling rate, food surface became dry and crust, moisture was slowly removed by moisture diffusion mechanism [26, 27].

Table 2: Effect of thickness (cm) of sweet potato chip on physicochemical and sensory properties of fried sweet potato chip

Thickness (cm)	Moisture (g/kg)	Oil (g/ kg)	Total phenolic (mg GAE/ g)	Total flavonoid (mg QE/g)	Carotenoid (mg BCE/g)	Sensory score
1.0	0.49±0.01^{b}	1.60±0.01^{b}	**1.62**±0.01^{b}	**0.75**±0.00^{b}	**0.050**±0.00^{b}	7.73±0.03^{ab}
1.5	0.52±0.03^{ab}	1.64±0.03^{ab}	1.65±0.01^{ab}	0.76±0.01^{ab}	0.051±0.00^{ab}	7.81±0.02^{ab}
2.0	**0.54±0.00^{ab}**	**1.67±0.00^{ab}**	**1.67**±0.02^{ab}	**0.79**±0.00^{a}	**0.052**±0.00^{a}	**7.89±0.02^{a}**
2.5	0.58±0.02^{a}	1.70±0.01^{a}	1.68±0.01^{a}	0.80±0.01^{a}	0.052±0.00^{a}	7.62±0.00^{b}

Data are expressed as mean ± SD values (n = 3). Mean value with different superscript in each column differs signifcantly (p<0.05)

From table 2, the sweet potato chip should be chopped into bars in 2.0 cm of thickness to achieve the best physicochemical and sensory properties of finished products during frying. Quality changes in different cultivars of sweet potato during deep-fat frying were monitored.14 Sweet potato chips were produced by vacuum-belt drying and compared to deep-fat fried (DFF) chips. Two thicknesses (0.8 and 1.5 mm) and four drying temperatures (100, 120, 140C and mixed temperature [T-mix] = 100/120/140C) were investigated. Vacuum-belt dried (VBD) chips exhibited a similar texture to those DFF while maintaining their natural color and β-carotene content. T-mix chips were found to have the greatest likability [15]. Investigation was carried out to study kinetics of moisture loss, oil uptake, lightness and textural changes during deep fat frying of sweet potato *(Ipomoea batatas L.)* chip. Sweet potato slides of 2mm thickness were fried in a laboratory scale fryer at different temperatures ranging from 120 to 150°**C** [17].

Effect of Packaging and Storage on Shelf Life of Fried Sweet Potato Chip

Shelf life is the time period in which a food product still retains its quality and safety and is acceptable to consumers. Shelf life evaluation of food stored under actual condition may take much longer time; hence an accelerated shelf life testing is often used for shelf life prediction [28].

Rancidity is often considered an unpleasant flavor in fried foods and can be indicated by the thiobarbituric acid (TBARs) value.

Table 3: Effect of packaging and storage on shelf life (thiobarbituric acid, mg malonaldehyde/ kg) of fried sweet potato chip

Storage (weeks)	Packing bag		Storage temperature	
	Zipper	**Vaccum**	**4oC**	**28oC**
0	0.52±0.01b	0.52±0.01b	0.52±0.01b	0.52±0.01b
4	0.53±0.01ab	0.52±0.01ab	0.52±0.01ab	0.54±0.01ab
8	0.56±0.00ab	0.53±0.02ab	0.53±0.00ab	0.55±0.03ab
12	0.58±0.03a	0.54±0.02a	0.54±0.02a	0.57±0.00a

Data are expressed as mean ± SD values (n = 3). Mean value with different superscript in each column differs signifcantly (p<0.05)

From table 3, fried sweet potato chip should be packed under vaccum and stored at 4oC to slow down the rancidity reaction. In one research, the vacuum fried pineapple chips packed in metalized polyethylene pouches with 100% nitrogen flushing were stored in accelerated conditions at 0, 25, 35 and 45°C for 12 weeks, it was found that observed changes in color and rancidity (TBARs) in pineapple chips were time and temperature dependence. The predicted shelf life of pineapple chips stored at 30°C based on the changes in TBARs was 30 weeks [24].

Shelf life of vacuum fried carrot chips stored at 0, 10 and 25°C. Based on the acid value changes during storage, they predicted shelf life of carrot chips at 55.3, 23.4 and 8.8 months, respectively [29]. Microwave-vacuum dried pomegranate arils packed in aluminum laminated polyethylene could be stored for 6 months at room temperature based on the accelerated conditions data under 38±1°C, 90±1% RH for 3 months [30]. In another study, effect of packaging and storage temperature on shelf life of potato crisps was monitored. The crisps were packaged into aluminium foil pack and polyethylene bags and stored at 25, 30, 35oC for 24 weeks. Aluminium foild pack was the most effective in controlling increase in moisture content, peroxide values and free fatty acid levels. Crisps stored at 35oC had significantly shorter shelf life compared to those stored at 25 and 30oC [31].

Conclusion

Sweet potato ranks as the world's seventh most important food crop, and has major contribution to energy and phytochemical source of nutrition. Sweet potato contains higher contents of carbohydrates, various vitamins, minerals, and protein than other vegetables. It also contains much higher levels of provitamin A, vitamin C and minerals than rice or wheat.

Contribution of sweet potato towards health is acknowledged due to high nutrient content and its anti-carcinogenic and cardiovascular disease preventing properties. Frying is one of the oldest processes of food preparation. Consumers have desired fried foods because of their unique combination of flavor and texture. The quality of the products from frying depends not only on the frying conditions, but also on the storage of fried sweet potato chip. This study demonstrated that frying temperature and time; thickness of sweet potato chip; packaging and storage temperature had signifcantly affected quality of fried sweet potato chips.

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