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Quality Attributes of Mango Chip by Vacuum Frying

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Vacuum frying is a frying process below atmospheric pressure. It better preserves the nutritional value, aroma, and color of the fried product. There is an increased demand for healthy fried chip with good taste, texture, and appearance. Nowadays, many health-conscious consumers prefer low fat foods. Mango possesses favourable nutritional components as an excellent source of phenolics, carotenoids and vitamin C, unique flavour, aroma and colour. In our research, mango slices were vacuum fried at 80/45, 85/40, 90/35, 95/30, 100/25 (ºC/minutes) at 15 kPa pressure. The prepared chips were analyzed for quality attributes. Mango chip fried at 90ºC in 35 minutes at 15 kPa maximum showed the lowest oil uptake and the highest ascorbic acid, total phenolic, firmness acceptability. The vacuum frying could be considered as an appropriate alternative to make mango chip with high nutritional values and required quality properties.

Keywords: Mango, vacuum frying, oil intake, ascorbic acid, total phenolic, firmness, overall acceptance

INTRODUCTION

Frying is a complex process popularly applied in the food industry. Food is immersed in oil at a higher temperature than the water boiling point in order to produce a vapor contraflow with the oil in the food surface (Bouchon et al. 2003). To limit oil absorption without losing organoleptic properties, various alternatives to the frying process have been introduced (Mellema, 2003; Ziaiifar et al., 2008). Vacuum frying is one of the innovative and effective processing methods used for agricultural products to make chips with better organoleptic and nutritional values (Savita and Bhotmange, 2019). It has been applied for different kinds of agricultural products, including apple, pineapple, mango, kiwi, jack fruit, apricot, papaya, banana, guava, casava, carrot, pineapple, mushroom, kiwi, apricot (Perez-Tinoco et al. 2008; Mariscal and Bouchon, 2008; Nunes and Moreira, 2009;Dueik et al. 2010; Diamante et al. 2011; Sothornvit, 2011;Maadyrad et al. 2011; Diamante et al. 2012; Saxena et al. 2012; Lemuelet al. 2012; Lastriyanto et al. 2013; Akinpelu et al. 2014;Garcia-Segovia et al. 2016;Aiqing et al. 2018; Savita and Bhotmange, 2019) in respect of oil absorption, moisture depletion and color development. In vacuum frying, heat transfer generates protein denaturation, starch gelatinization, water vaporization, crust formation and, color development, which are typical phenomena of the combination effect of multiple chemical reactions (Rafael et al. 2012). Factors influencing vacuum-fried fruit quality attributes are the type of equipment, pre-treatments, processing conditions, fruit type, and fruit matrix (Fitriyono et al. 2018). Time, temperature, and vacuum pressure influenced color, texture, nutrients, and oil content of fried fruits (Bravo et al. 2011; Villamizar et al. 2012; Akinpelu et al. 2014). Vacuum frying has been reported to delay deterioration of frying oil quality (Wanakamol and Poonlarp, 2018).

Mango *(Mangiferaindica L.)* is a popular fruit due to its sweet taste and high nutrient content (Nguyen et al. 2019).It is rich in phytochemical constituents such as alkaloids, terpenoids, saponins, tannins, phenolics and flavonoids protecting consumer health from the detrimental effect of free radicals. It is rich in beta-carotene, ascorbic acid, antioxidants and, therefore, reduces the risk of cardiac disease, *anti-diabetic,* anticancer, *anti-inflammatory* and antiviral activities (Abbasi et al. 2011; Kalpna et al. 2016; Masud, 2016; Arshad et al., 2016; Lalisa et al. 2017; John et al., 2017). Mango fruit is fresh during the harvesting season but perishable quickly under the prevailing conditions of temperature and humidity as well as lack of adequate storage facilities (Nguyen et al., 2019). Purpose of our research penetrated on the vacuum frying treatment to quality attributes such as oil intake, ascorbic acid, total phenolic, firmness, overall acceptance of fried mango chips.

MATERIALS AND METHODS

Material

Mango fruitswere collected from SocTrang province, Vietnam. After collecting, they must be kept in dry cool place and quickly conveyed to laboratory for experiments. They were subjected to washing, cutting into thin slices and oil frying. Soybean oil was used for frying with product to oil ratio 1: 15.

Researching method

500 g of mango slices was arranged in perforated basket and hanged with a stainless-steel lift rod. They were fried under different conditions: 80/45, 85/40, 90/35, 95/30, 100/25 (^{o}C/minutes) at 15 kPa pressure. After frying, the basket was raised, stirred manually, the vessel was pressurized up to atmospheric pressure and the samples were centrifuged for 10 minutes at 500 rpm to remove excess oil. Treatments were replicated three times.Chips were evaluated oil intake, ascorbic acid, total phenolic, firmness, overall acceptance.

Physico-chemical and sensory analysis

Oiluptake(%) was determined by using soxhlet extraction apparatus (AOAC, 1995). Ascorbic acid content (mg/100g) was analyzed by 2,6 Dichloroindophenol dye by titration method (Ranganna, 2001). Total phenolic content (TPC, mg GAE/100g) was determined calorimetricallyusing Folin-Ciocalteu reagent (Hassan and Bakar, 2013). Firmness and overall acceptance were evaluated as sensory score by a group of panelists using 9 point-Hedonic scale.

Statistical analysis

The experiments were run in triplicate with three different lots of samples. The data were presented as mean±standard deviation. Statistical analysis was performed by the Statgraphics Centurion version XVI.

RESULTS ANDDISCUSSION

Frying is one of the most popular processing methods used for agricultural products (Savita and Bhotmange, 2019). Vacuum frying is normally conducted at pressure below the atmospheric level, lowering the boiling point of water and therefore, significantly reducing the frying temperature (Garayo and Moreira, 2002). Oil uptake occurs mainly after frying: by the lower pressure in the pores, the oil present on the surface of the chips is absorbed into the pores. As presented in figure 1, oil uptakes (%) of vacuum fried mango chips at 80/45, 85/40, 90/35, 95/30, 100/25 (^{o}C/minutes) was in range of 15.31% to 19.67%. The lowest oil uptake was noticed by vacuum frying at 90^{o}C for 35 minutes. Our results were similar to other findings on potato, jackfruit, shrimp, guava (Garayo and Moreira, 2002; Maity et al. 2014; Pan et al. 2015; Savita and Bhotmange, 2019). Increasing temperature from 70 to 90 °C and time from 35 to 65 min results in an increased oil content for gold kiwi fruit (Diamante et al. 2013). In another report, increasing temperature from 112 to 136 °C and time from 3 to 9 min results insignificant increase of oil content in plantain (Akinpelu et al. 2014).

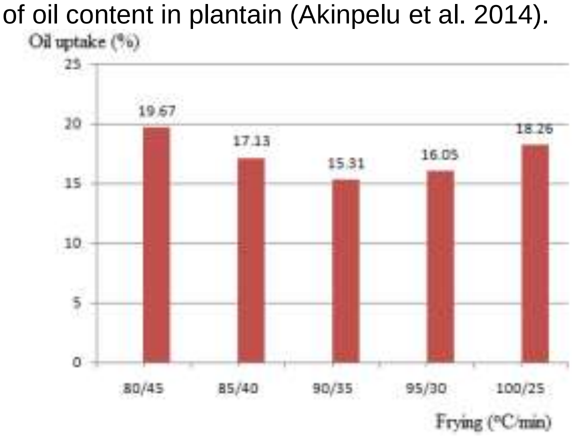

Figure 1: Effect of vacuum frying (^{o}C/min) to oil uptake (%) in fried mango chips

Mariscal and Bouchon (2008) found that increasing temperature from 95 to 115 °C induces structural changes such as tissue degradation that enhanced the oil absorption in apple chips. Oil absorption was highly correlated with moisture loss in vacuum-fried apple slices (Shyu and

Hwang, 2001). By prolonging the frying, the dried surface becomes more hydrophobic which facilitates the oil absorption (Fitriyono et al. 2018).

The ascorbic acid contents (mg/100g) ofvacuum fried mango chips at 80/45, 85/40, 90/35, 95/30, 100/25 (°C/minutes) were in range of 15.79% to 17.45%. Vacuum frying at 90°C for 35 minutes revealed the highest ascorbic acid retention. Degradation of ascorbic acid content of fried mango chips by thermal treatment is due to heat sensitivity. Our results were similar to findings on kiwi, potato and apple slices. Vitamin C content of the vacuum-fried gold kiwifruit and apple was decreased as the temperature increased from 70 to 90 °C (gold kiwifruit) and 160 to 180 °C (apple) because of heat sensitivity of vitamin C. An increasing frying time from 35 to 55 min of vacuum-fried gold kiwifruit was found to have only a slight effect on vitamin C (Dueik and Bouchon, 2011; Diamante et al., 2012).

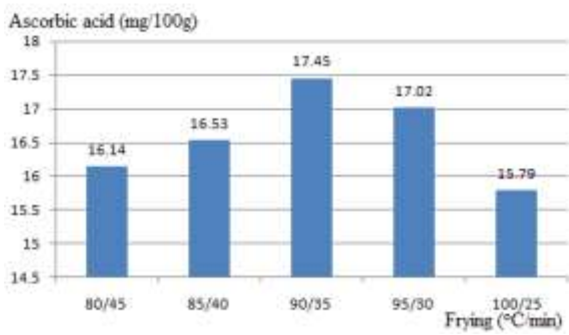

Figure 2: Effect of vacuum frying (°C/min) to ascorbic acid content (mg/100g) in fried mango chips

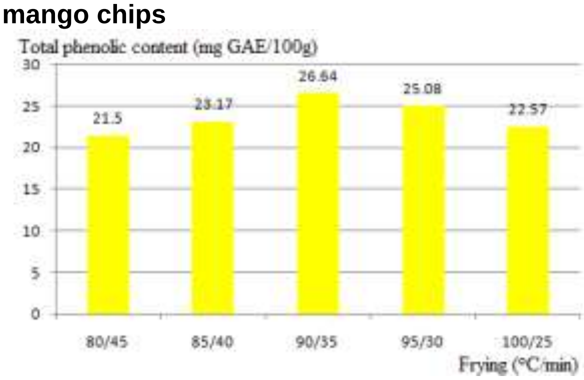

Figure 3: Effect of vacuum frying (°C/min) to total phenolic content (mg GAE/100g) in fried mango chips

As presented in figure 3, total phenolic contents (mg GAE/100g) of vacuum fried mango chips at 80/45, 85/40, 90/35, 95/30, 100/25 (°C/minutes) were in range of 21.5% to 26.64%. Vacuum frying at 90°C for 35 minutes revealed the highest total phenolic retention. This frying treatment presereved maximum amount of phytochemicals in fried chips by limiting their oxidation and thermal decomposition (Chen and Chin, 2007; Materska, 2010).

At the beginning of the frying, fruit tissue became soft due to cell rupture and solubilization of the middle lamellae and lead to rubbery and soggy products. Continuing the frying, the rapid loss of moisture from the surface lead to crust formation and an increase of the maximum breaking force. In the final stages of the process, the crust thickened until the end of the process (Yamsaengsung et al., 2011). During frying, moisture was removed from the mango slices resulting in textural changes. As presented in figure 4, firmness values (sensory score) of vacuum fried mango chips at 80/45, 85/40, 90/35, 95/30, 100/25 (°C/minutes) were in range of 6.11 to 8.15. Vacuum frying at 90°C for 35 minutes revealed the highest value of textural firmness. Shyu and Hwang (2001) found that increasing of frying time (from 5 to 30 min) leads to a higher crispness of apple chips. Increase in texture crispiness positively affected the acceptability of product (Savita and Bhotmange, 2019). Lower the breaking force higher will be the crispiness (Fan et al. 2005; Quan et al. 2014). Textural firmness was the result of fast gelatinization of starch granules in contact with hot oil and the transformation of its superficial structure in a crunchy crust (Rafael et al., 2012).

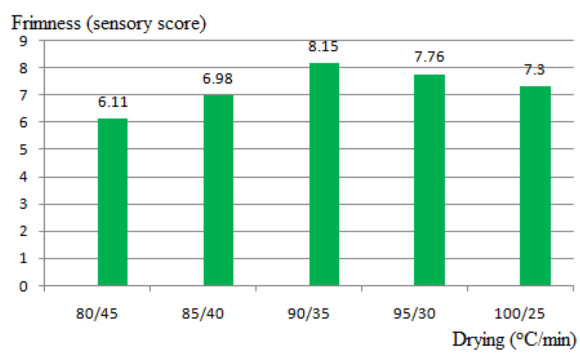

Figure 4: Effect of vacuum frying (°C/min) to firmness (sensory score) of fried mango chips

As presented in figure 5, overall acceptance (sensory score) of vacuum fried mango chips at 80/45, 85/40, 90/35, 95/30, 100/25 (°C/minutes) were in range of 6.57 to 8.52. Vacuum frying at 90°C for 35 minutes gave the highest overall acceptance. Rafael et al. (2012) found that best treatment was to 0.5 bar, 110 °C y 90s of immersion time for mango snack. The low thermal treatment and limited exposure to oxygen in the vacuum frying contribute to different advantages, such as nutrient retention, oil quality preservation, limitation of acrylamide formation, protection of natural pigments and aroma with lower water activity (Granda et al. 2004; Shyu et al. 2005; Da Silva and Moreira, 2008). Mango chips under atmospheric frying had less carotenoid retention than those under vacuum frying (Yolanda and Rosana, 2009).

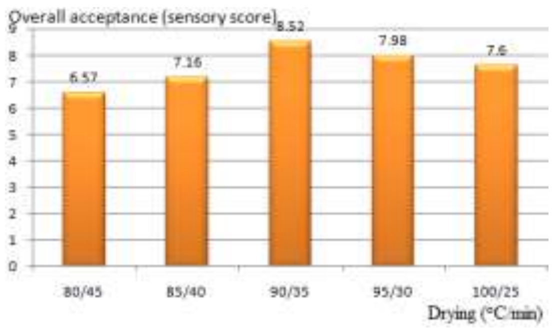

Figure 5: Effect of vacuum frying (ºC/min) to overall acceptance (sensory score) in fried mango chips

CONCLUSION

Mango (*Mangiferaindica* L.) fruit is rich in aroma and nutritional values, which is an excellent candidate for making chips. Vacuum frying of mango fruit enables frying at lower temperatures compared to atmospheric frying, thereby improving quality attributes of the fried product, such as oil uptake, vitamin, phytochemical, texture and overall acceptability. In this research, we have successfully examined the effectiveness of temperature and time during vacuum frying to physico-chemical and organoleptic attributes of fried mango chips. They are appreciated because of their unique flavor and texture. Vacuum frying transforms a perishable mango fruit to more stable and value added form. Therefore, production of chip from this fruit by vacuum frying will significantly reduce post-harvest losses.

CONFLICT OF INTEREST

The authors declared that present study was performed in absence of any conflict of interest.

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AUTHOR CONTRIBUTIONS

Nguyen Phuoc Minh arranged the experiments and also wrote the manuscript.

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