Journal of Tropical Agriculture 55 (2): 161-166, 2017

Effect of pre-treatments on quality parameters of vacuum fried ripened banana (*Nendran*) chips

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Received 7 October 2017; received in revised form 22 November 2017; accepted 18 December 2017

Abstract

India is the major producer of banana in the world. Ripened banana chips is the favourite snack of the consumers of all age groups. In the present study, attempts were made to improve the quality and reduce the residual oil content of vacuum fried ripened banana chips through pre-treatments *viz.,* blanching cum drying, gum coating, and freezing. The quality attributes like oil absorption, moisture content, water activity, texture, colour and sensory values were determined for all the products treated at frying temperature, pressure and time of 100º C, 20 k Pa and 10 min, respectively. The blanching cum drying pre-treatment showed significant ($p<0.0001$) oil reduction but exhibited poor consumer acceptability. However the freezing pre-treatment scored high consumer acceptability with high oil content of 38.2%. The gum coating pre-treatment was on par with untreated vacuum fried chips. Untreated vacuum fried chips with post centrifugation at 1000 rpm for 5 min had low residual oil content of 13.4% and good consumer acceptability. Analysis revealed that untreated products were superior not only in terms of quality but also in terms of reduced cost and time for the protocol.

Keywords: Pre-treatments, Ripened banana chips, Vacuum frying

Introduction

India is the largest producer of banana in the world with a production area of 776 hectares and a production capacity of 29.7 million tonnes (GOI, 2017). Banana, *The Apple of Paradise,* is the climacteric fruit that produces ethylene after harvest, ripen rapidly and is highly prone to storage loss (Uma and Shanmugam, 2015). The estimated post-harvest loss in fruits and vegetables is 5 to 30 per cent of its total production (FAO, 2015). The estimated loss for banana was 10-12 per cent (GOI, 2017), the main reason being its improper post-harvest handling and its specific storage temperature requirement of 12-14° C which demanded a separate cold storage chamber. A pragmatic solution for reducing the post-harvest loss in *Nendran* banana is the adoption of suitable processing strategies.

Banana chips is the flagship product among its processed products and are known as '*The taste of Kerala'*. These fried products are an inevitable component of marriages and traditional celebrations of the state. The presence of high oil content in fried snacks is often a deterant to product quality and is disadvantageous to consumers and producers in terms of profit margin based on reusable cycle (Oginni et al., 2014). The development of superior quality fried products with minimum oil is of great interest to food industry and to consumers. Vacuum frying is a promising alternative frying technology to improve the quality of fried products (Song et al., 2007). During vacuum frying, the sample is heated under a negative pressure that lowers the boiling and smoking points of water and oil (Troncoso et al., 2009). It is note worthy that adoption of vacuum frying technology could lead to a remarkable

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reduction in the concentration of acrylamide, a potential carcinogen.

There has been no attempts to explore the vacuum frying of ripened Nendran banana. Hence, the present study was undertaken to develop vacuum fried ripened *Nendran* banana chips through adoption of pre-treatments like gum coating, blanching cum drying and freezing compared to untreated and atmospheric fried banana chips.

Materials and Methods

Ripe banana (cultivar: *Nendran*) procured from local market, Kerala and rice bran oil (Brand: Pavizham, India) were used for the study. The experiment was carried out in vacuum frying machine equipped with de-oiling mechanism developed under Centre of Excellence in Post-harvest Technology, Department of Food and Agricultural Process Engineering, Kelappaji College of Agricultural and Engineering Technology, Kerala Agricultural University, Tavanur.

Preparation of sample for pre-treatments

Bananas were cleaned, peeled manually and sliced in banana slicer (Make: Balakrishna, India) to a thickness of one mm. The sliced banana samples were water blanched for two min (Troncoso et al., 2009) and dried at 65ºC for 3 h (Samatcha et al., 2010) and fried. The guar gum coating was prepared by dissolving 1.5% of guar gum in distilled water at 90º C for 30 min (Sothornvit, 2011). The application of gum on sliced banana was done by dipping it for 5 min in the gum solution. Freezing was done in a deep freezer (Make: Kemi, India) at -18° C for overnight (12 h) (Fan et al., 2005).

Vacuum frying was carried out at constant frying temperature, time and pressure of 100º C, 10 min, and 20 k Pa, respectively. Pre-treated and control samples were centrifuged using de-oiling motor (Make: Prime motors, India) at 1000 rpm for 5 min (Ranasalva and Sudheer, 2017). The three pre-treatments were compared with untreated vacuum fried samples as well as with atmospheric fried samples (control).

Determination of quality parameters

The oil content (AOAC, 1997) and moisture content (AACC, 1986) of the vacuum fried ripened banana chips were determined. Water activity of chips was determined using water activity meter (Aqua Lab). Hardness of the chips was assessed using Texture analyzer (Stable Micro systems, TA HD Plus) with the ball end probe Test conditions (Mode : Measure Force in Compression, Option : Return to Start, Pre-Test Speed : 1.0 mm s^{-1}, Test Speed : 1.0 mm s^{-1}, Post-Test Speed : 10.0 mm s^{-1}, Strain : 40%, Data Acquisition Rate : 500 pps, Probe : ball end probe model P 5 S^{-1} with 5 kg load cell). The banana chips to be tested were placed in the specific sample holder recommended for fried food products. The compression force required to fracture the surface cell structure of banana chips was obtained using Texture Expert software (Version 3.5.0.). Texture analysis was repeated using 15 replicates to attain accurate result. The colour values of the chips were determined using colorimeter (Hunter Lab: Color flex EZ) as L*, a* and b*, where L* represent lightness value ranging from 0 to 100 (Black to white), a* represents redness (-60 to 60, green to red), and b* represents yellowness (-60 to 60, blue to yellow). The chips were crushed to granules to obtain uniform colour values. All the experiments were replicated thrice.

Sensory analysis was carried out for 9 point Hedonic scale by 12 semi trained panelists for the sensory attributes like colour, crispness, appearance, flavour and over all acceptability (Ranasalva and Sudheer, 2017).

Statistical analysis

The results were analyzed statistically using Design Expert version 7.0. general factorial method.

Results and Discussion

The changes in quality attributes of vacuum fried ripened bananas that were provided with different pre-treatments were compared with untreated and control samples (Table 1) and are detailed below.

Table 1. Treatment details of vacuum fried ripened banana chips

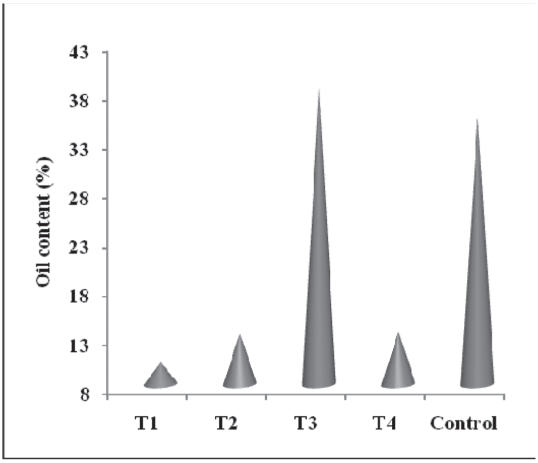
Vacuum fried ripened banana chips	Pre-treatments
T1	Blanching cum drying
T2	Gum coating
T3	Freezing
T4	Untreated
Control	Atmospheric fried ripened banana chips

Oil content

The pre-treatments significantly ($p<0.0001$) affected the oil content of vacuum fried ripened banana chips and the oil content was significantly lower than the atmospheric fried chips. The oil content was highest (38.2%) in frozen (T3) pre-treatment. The rapid formation of microstructure pores during the evaporation of ice crystals on frying facilitated high oil absorption. The results obtained were in agreement with Albertos et al. (2016), who observed increased oil absorption in vacuum fried carrot chips pre-treated with freezing. The lowest oil content of 10.21% was observed in samples were pre-treated with blanching cum drying (T1). This reduced oil content was directly related to moisture loss of dried banana slices, that facilitated low oil absorption on frying. Gamble et al. (1987) reported similar result with deep fat frying of tubers that were dried before frying. The oil content of gum coated products (T3) was 13.14%. The reduction in oil content attained through gum coating pre-treatment was slightly higher than de-oiled chips without pre-treatment.

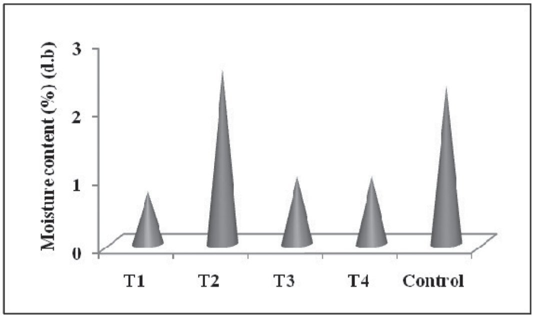
Moisture content and water activity (a_w)

Moisture content (Fig. 2) and water activity of vacuum fried ripened banana chips varied significantly ($p<0.0001$) with pre-treatments. The



Significant at 1% level

Figure 1. Oil content of pre-treated vacuum fried ripened banana chips



Significant at 1% level

Figure 2. Moisture content of pre-treated vacuum fried ripened banana chips

moisture content was highest (2.56%) in gum coated pre-treatment. The banana slices pre-treated with gum coating inhibited the moisture evaporation by forming a film over the surface, leading to high moisture content in vacuum fried banana chips. The result was in confirmation with the study of Pawar et al. (2014) on hydrocolloids treated *kachori* on deep fat frying. Lowest moisture content (0.76%) was observed in chips pre-treated with blanching cum drying. The initial moisture removal of banana slices through drying contributed to low moisture content in the vacuum fried banana chips. Similar trend of low moisture content was observed in deep fat fried potato chips that were dried prior to frying by Pedreschi and Moyano (2005). The moisture content of frozen

(T3) and untreated (T4) samples was 0.96% and 0.98%, (*w.b*) respectively. The frozen pre-treated treatments exhibited highest moisture removal. This was due to rapid removal of moisture on vacuum frying of frozen samples with high temperature gradient. Shyu et al. (2005) presented similar trend of moisture reduction in vacuum fried carrots chips pre-treated with freezing. The moisture content of control was 2.31%, which was higher than untreated (T4) and less than corresponding gum coated pre-treatments.

The water activity varied significantly ($p<0.0001$) with pre-treatments. The a_w values ranged between 0.21 to 0.34 which were adjudged to be well below the tolerance limit and within the safe level. The obtained results were supported by the study conducted on vacuum fried carrot chips by Dueik et al. (2010). Since deep fat frying cooking method was the fastest dehydration process, the vacuum frying as well as atmospheric frying exhibited safe level of moisture and a_w for storage.

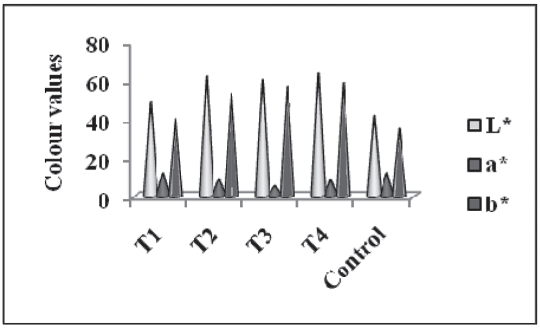
Colour values

The colour attributes showed significant variation ($p<0.0001$) with pre-treatments (Fig. 3). The L^* was maximum (60.28) for frozen (T3) pre-treatment and minimum (52.58) for blanching cum drying (T1). This indicated that frozen pre-treatment produced significantly light coloured fried product, where as dark coloured product was obtained from blanching cum drying pre-treatment. This colour degradation in blanching cum drying pre-treatment was due to drying process that darkens the colour of the product. The observations of Fan et al. (2005) on lighter coloured vacuum fried carrot chips, pre-treated with freezing than that of drying, was similar to the result of present study.

The chips that were pre-treated with blanching cum drying showed highest a^* value (11.46) and the gum coated one revealed highest b^* (49.53). This indicated increase in darkness of the product on blanching cum drying pre-treatment. The product obtained from gum coated pre-treatment was with high yellowness. Similar trend was observed in colour values of hydrocolloid coated vacuum fried jack fruit chips (Maity et al., 2015). The overall colour change (ÄE value) ranged between -2.21 to -15.17. The Yellowness index was observed to be maximum (130.2) during pre-treatment with gum coating followed by freezing (110.57) and blanching cum drying (104.27). The gum coating and freezing pre-treatments showed acceptable colour values compared with blanching cum drying. It was also observed that the colour values of control were on par with frozen and gum coat pre-treatment.

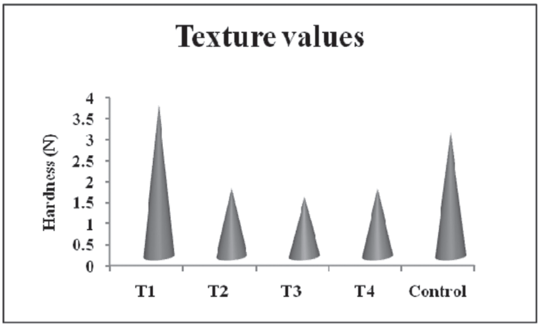
Textural changes

A higher hardness value of 3.54 N was observed in blanching cum drying pre-treatment (Fig. 4). The removal of moisture prior to frying made the product compact and hard (Debnath et al., 2003).



Significant at 1% level

Figure 3. Colour values of pre-treated vacuum fried ripened banana chips



Significant at 1% level

Figure 4. Texture values of pre-treated vacuum fried ripened banana chips

The chips pre-treated with freezing were more crispier with lowest hardness value of 1.42 N. The retention of moisture in the frozen banana slices increased the rate of mass transfer with high oil absorption that favoured crispness in the product. Similar improvement in texture of vacuum fried kiwi fruit, with frozen pre-treatment was reported by Diamante et al. (2011). The hardness value of gum coated vacuum fried banana chips were on par with the untreated samples (Fig. 4). The result of Bouaziz et al. (2016) on almond gum coated deep fat fried potato chips revealed similar trend of textural change.

Sensory evaluation

The sensory preference of pre-treated vacuum fried ripened banana chips was significantly higher than the control (Fig. 5). The gum coating pre-treated and untreated scored the highest overall acceptability (8.5). The sensory attributes score of these were 7.5 for texture, and 8 for other three attributes *viz.,* colour and appearance, taste and flavour. This was followed by a sensory score of 8.2, for frozen pre-treatment. The overall sensory score for control was recorded as 7.5. Poor score of 5 was noted in blanching cum drying pre-treated vacuum fried ripened banana chips due to consumer's unacceptability. The colour and appearance attribute ranked first among the sensory attributes due to its retention of yellow colour without darkening in the frozen and gum coating pre-treatments.

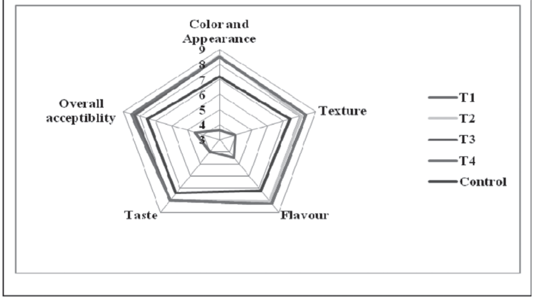


Figure 5. Sensory values of pre-treated vacuum fried ripened banana chips

The quality attributes of pre-treated vacuum fried ripened banana chips was on par with the untreated chips. Though chips fried with blanching cum drying pre-treatment possessed low oil content than other pre-treatments, it was rated poor in consumer acceptability. The freezing pre-treatment exhibited higher sensory score with higher oil absorption and high yellowness index. The gum coating pre-treatment was on par in all the quality attributes with untreated vacuum fried chips. In view of the various quality parameters and consumer acceptability, vacuum fried banana chips without pre-treatments was considered best as it bypasses the pre-treatment protocol saving energy, operational cost and time.

Acknowledgements

The authors acknowledge the financial support from the government of Kerala through Sate Planning Project "Centre of Excellence in Post-harvest Technology" and the technical support of Kerala Agricultural University.

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