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EFFECT OF POST CENTRIFUGATION (DE-OILING) ON QUALITY OF VACUUM FRIED BANANA CHIPS (NENDRAN)

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ABSTRACT

Vacuum frying has been proven to be a promising technology in food industry to produce quality products with low oil content. The effect of centrifugation for de - oiling of vacuum fried banana chips to reduce the oil content. The idea of present work is to determine the effectiveness of centrifuging speed (400, 600, 800, 1000 rpm) and duration (0, 3, 5, 7, 9 min) on quality attributes of vacuum fried banana chips. The frying temperature, pressure and time are remained constant for all the treatments as 100ºC, 20 kPa and 10 min. The effect of centrifugation speed (400, 600, 800, 1000 rpm) and duration (0, 3, 5, 7, 9 min) on quality attributes of vacuum fried banana chips was noted. The quality attributes like moisture content (0.93% w.b), oil absorption (10.21%), water activity (0.2), texture (2.43 N), colour values L^* and sensory were determined as. The oil content of centrifuged banana chips exhibited 90.9% reduction for maximum centrifuging speed. No significant changes ($p < 0.05$) were noted in the sensory analysis of the banana chips. A significant ($p < 0.05$) reduction of oil content was observed when the vacuum fried banana chips centrifuged at 1000 rpm for 5 min.

INTRODUCTION

Banana chips designate a remarkable snack in Indian snack market. Frying intends to secure the flavour and nutrients within crispy curst formed during frying. High fat snacks are liable to cause several coronary heart disease, high blood cholesterol, diabetes and obesity etc (Moreira *et al.*1995; Haghshenas *et al.,* 2014). An alternate frying condition, frying under vacuum is a recently thriving technology, entails in low oil uptake in fried product (Garayo and Moreira, 2002). Conversely, Troncoso *et al.* (2009) noted an increases the oil absorption of fried product due to "sponge effect" in vacuum fried potato chips than atmospheric fried chips. Besides, Pan *et al.,* (2015) confirmed that vacuum frying of breaded shrimp contain low oil than atmospheric frying. In another study conducted by Aida *et al.,* (2016) reduced the oil absorption of banana chips by pre-treating it with 0.66% of sugar solution. Edible coating of with basil seed gum reduced 34.5% of oil absorption in fried shrimp (Khazaei *et al.,* 2016). Use of hydrocolloids reduced the oil absorption in potato strips (Kim *et al.*, 2011). Troncoso *et al* (2009) compared the difference between vacuum and atmospheric fried potato chips pre-treated with sulfites, blanching and drying. Pawar *et al.,* (2014) found 1.5% of carboxyl methyl cellulose (CMC) reduced oil content in fried kachori. Garmakhany *et al.,* (2014) produced low fat french-fries with the edible blended coating of 0.5% of CMC and pectin. John and Hathan (2014) reported the reduction in oil content of taro chips with 1.5% of methyl cellulose. Maity *et al.,* (2015) reduced the oil absorption using hydrocolloids in vacuum fried jack fruit chips, in another study Gayathri and Sathyanarayana (2016) used vacuum packaging technology to extend the shelf life of jack fruit bulbs. Sothornvit (2011) investigated on vacuum frying of bananas coated with hydrocolloids and centrifuged at 280 rpm while studies on quality changes for de – oiled banana chips under vacuum frying is hardly found.

Indeed vacuum frying shows increase in oil content due to the oil kinetics during post frying process. The de-oiling mechanism is an essential step in frying process in since the pressure gradient immediately after frying is created which provokes a driving force on the surface oil to permeate into the core. Moreira *et al.* (2009) difference oil in content between surface and core of de-oiled and non de-oiled potato chips. It was determined that only 14% of oil was present inside the core, while massive 86% was on surface. This confirms the necessity of de-oiling through which majority of surface oil can be removed. So, effect of post centrifuging for vacuum fried ripe banana chips on its quality especially the oil absorption is inevitable.

This study was carried out with insight of reducing oil content and improving the quality of fried banana chips. Vacuum frying with post centrifuging would act as an effective technology in achieving low oil content. The paper aims at determining oil absorption kinetics of ripe banana chips with different post centrifuging speed and duration measuring the physical quality parameters of fried ripe banana chips under different de-oiling duration and speed.

MATERIALS AND METHODS

Ripe Banana (cultivar: *Nendran*) was procured from KCAET farm Kerala Agricultural University, Kerala. The ripening index suitable for vacuum frying was standardized based on oil absorption at different stage. The rice bran oil (Brand: PAVIZHAM, INDIA) was used for frying. 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, Kerala Agricultural University.

Sample preparation

Bananas were cleaned and peeled manually and sliced in banana slicer (Made: BALAKRISHNA, INDIA) to a thickness of 1 mm. The samples are tested for its TSS (Total soluble sugars) using digital refractometer (Mandal *et al.,* 2016). The optimized TSS suitable for deep fat frying was 20 - 24ºB by conducting preliminary trials. The bananas with high sugar content were found to be oily, while banana with less TSS tastes unpleasant. The optimum ripeness of banana suitable for deep fat frying was decided based on its TSS content.

Vacuum Frying

A batch type vacuum frying system developed under Kerala Agricultural University KAU), was mainly consists of two compartments oil storage and frying chambers. Both the chambers are of similar capacity (30 litre) stainless steel (No. 316) which can be heated electrically and control system was provided to maintain frying conditions. The vessel was completely sealed using screws and lock system to create vacuum. The pressure maintained in vacuum frying chamber was 20 kPa, boiling point of water at this pressure is 60ºC. Temperature of frying oil was maintained at 100ºC throughout the process. The sliced bananas was fed into frying basket and fixed using the provision provided with frying chamber. The frying time and temperature was retained to be constant, varying the temperature and time of frying generate changes in quality parameters which would affect the determination of influence of centrifuging on product quality. The product to oil ratio for frying was 1:6 as Sothornvit (2011) optimized the ratio of product and frying oil for deep fat frying of banana chips. The oil was pre-heated prior to frying in the storage chamber and was transferred to the frying chamber. The filtered oil was used prior to each trial to remove the fried leftovers. Frying was carried out at constant frying temperature 100ºC, time 10 mins and pressure 20 kPa. During frying the frying basket connected with a motor (1/2 HP) rotates at 30 rpm to give a movement for uniform frying. The oil is collected back into the storage tank after completion of frying. The basket with fried banana was centrifuged at once after accomplishment of transfer of frying oil from frying chamber. The fried bananas were centrifuged at varying rpm (400, 600, 800 and 1000 rpm) and duration (3, 5, 7 and 9 min). The fried samples were packed in LDPE standup pouches for further quality analysis.

Determination of oil content

The oil content of the fried banana chips with different post centrifuging parameters were determined using AOAC (1997) method in automatic Soxhlet apparatus (MAKE: Pelican Equipments, Soc plus MODEL: SOCS 06 ACS INDIA) connected with microprocessor control for operating the apparatus. (Carla and Moreira, 2011; Aida *et al.,* 2016).

$$\text{Oil content in (\%)} = \frac{\text{(Initial weight - Final Weight}}{\text{Final weight}} \times 100$$

Determination of other quality attributes

The moisture content of fried banana chips was determined using (AACC, 1986), weight loss of banana chips drying in a forced convective hot air oven for 105ºC for 72 hrs. Water activity of fried banana chips was determined using water activity meter (AQUA LAB,) (Dueik *et al*, 2010). The hardness of the chips was using Texture analyzer (Stable Micro systems. TA HD Plus, USA) with the ball end probe (probe model P 5/S). The banana chips to be tested were placed in the specific sample holder recommended for fried food products (Mayyawadee and Gerhard, 2011). The compression force required to fracture the surface cell structure of banana chips was obtained using Texture Expert software (Version 3.5.0.). Each analysis was experimented using 15 samples to attain accurate result. The colour values of the chips were determined using colorimeter (HUNTER LAB: Color flex EZ) L^*, a^* and b^*. Where L^* representing lightness value ranges between 0 to 100 (Black to white) a^* represents redness (-60 to 60, green to red) b^* represents yellowness (-60 to 60, blue to yellow). The chips were crushed to granules to obtain uniform colour values (Maity *et al.,* 2015).

The bulk density, true density and porosity were determined using standard methods and formulas (Carla and Moreira, 2011). Sensory analysis was carried out for 9 point hedonic scale by 12 semi trained panellists for the sensory attributes colour, crispness, appearance, flavour and over all acceptability. The results were analyzed statistically using Design Expert version 7.1. (Kothakota *et al.,* 2015) general factorial method.

RESULTS AND DISCUSSION

Effect of centrifugation on de-oiling

The centrifugation of fried banana chips was done under vacuum immediately after frying. The oil from frying chamber was transferred into oil storage chamber once the product was done with frying. From the graph (3.1) it can be elucidated that with progression in centrifuging speed and oil content of the fried banana chips was reduced. Minimum percentage of oil content 16.35% was observed at post centrifuging speed of 1000 rpm at 5 minutes, prolonging the centrifuging duration to 7 and 9 min does not show significant variation in oil content reduction.

The maximum reduction of 90.9% was observed under post centrifuging at 1000 rpm for 5 min compared with non centrifuged fried product. The low centrifuge speed of 400 rpm showed reduction in oil content ranges from 74.4 - 80.03%, centrifuging speed of 600 rpm exhibited still more oil reduction of 77.85 - 85.62% and 800 rpm observed with further reduction of oil reduction from 78.86 - 87.09% also showed notable reduction of oil content. The work of Maity *et al*, 2014 supports the obtained trend of oil reduction, where vacuum fried jack fruit centrifuged at 500 rpm for 8 min showed 70% reduction in oil content from control sample. Similar reduction pattern in oil content was observed in apple chips fried under vacuum by Shyu and Hwang (2001). It was

Table 3.1: Colour values of banana chips at different centrifuging parameter

Time in min	L*				a*				b*			
	Centrifuging speed in rpm											
	400	600	800	1000	400	600	800	1000	400	600	800	1000
0	49.83^{a}	49.83^{a}	49.83^{a}	49.82^{a}	9.24^{a}	9.24^{a}	9.24^{a}	9.24^{a}	34.3^{a}	34.3^{a}	34.3^{a}	34.3^{a}
3	51.75^{b}	50.85^{b}	50.91^{b}	59.1^{c}	9.65^{a}	9.71^{a}	8.48^{b}	10.27^{b}	36.72^{b}	36.33^{b}	38.92^{c}	37.62^{b}
5	53.7^{c}	54.36^{c}	54.15^{c}	60.71^{d}	8.34^{b}	8.91^{a}	7.48^{c}	9.7^{a}	36.93^{b}	39.35^{c}	40.66^{c}	41.16^{d}
7	53.2^{c}	55.38^{c}	59.29^{d}	63.6^{e}	7.93^{c}	7.48^{c}	7.32^{c}	8.46^{b}	38.54^{c}	41.07^{d}	41.91^{d}	42.43^{d}
9	54.83^{c}	56.86^{c}	60.53^{d}	63.21^{e}	7.43^{c}	7.21^{c}	7.85^{c}	7.28^{c}	39.12^{c}	42.83^{d}	43.32^{d}	46.21^{e}

Values with different superscripts within columns differ significantly ($p < 0.05$).

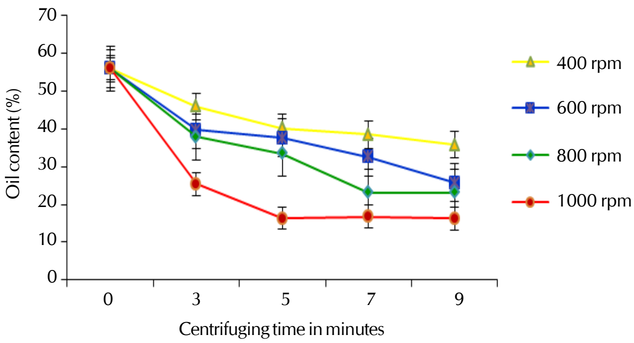


Figure 1: Effect of Centrifuging on oil content of banana chips

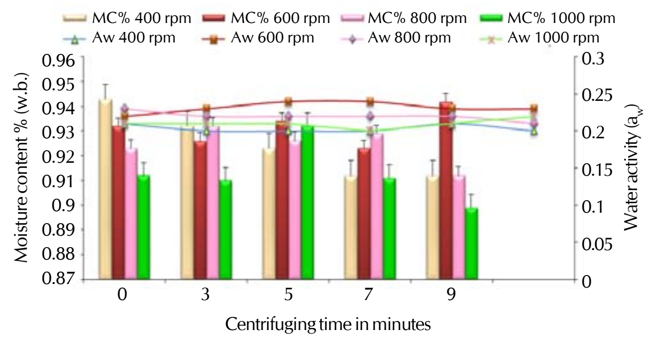


Figure 2: Changes in Moisture content and water activity

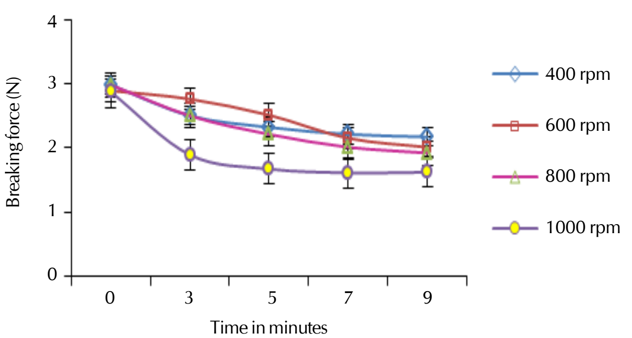


Figure 3: Textural changes with varying centrifuging parameter

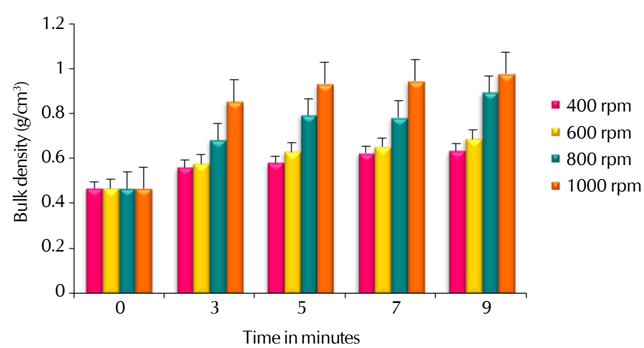


Figure 4: Bulk density of vacuum fried banana chips

confessed that de-oiling with centrifuging speed of 280 rpm showed 33.5% reduction whereas at 140 rpm 17.31% reduction was observed (Moreira *et al.* 2009). This remarkable reduction of oil with association of increased centrifuging speed and time was probably due to comprehensive removal of surface oil through the pores. During centrifuging the high density oil gets rid of ridges and pores of fried product through capillary. This leads to very meager retention of oil in centrifuged products. Statistical analysis showed significant effect ($P < 0.05$) on oil content by centrifuging speed and duration.

Moisture content and water activity

The measurement of moisture content determines the effectiveness of dehydration through frying at particular temperature and time. The initial period to attain the boiling temperature plateau is very short under vacuum frying (Garayo and Moreira, 2002). This phenomenon enables efficient evaporation of moisture from the product to oil due to reduced pressure than other drying process. The Fig. (3.2) below depicts the values of moisture content and water activity. It is clear from the table values that the changes in centrifuging parameter do not affect the moisture content (0.983 to 0.892% w.b) and water activity significantly. The water activity of fried chips ranges from 0.234 to 0.257. Similar value of water activity was studied by Sothornvit (2011) on edible gum coated banana chips with guar and xanthan gum was 0.224. The determined moisture content is potent enough to resist the microbial growth.

Textural changes in banana chips

The texture pattern observed in banana chips was jagged force deformation; similar pattern was recorded by Mayyawadee and Gerhard (2011) on cassava crackers. The compression force increased linearly until the first fracture of banana chips, it drops after reaching a peak force which is considered as hardness value. The compression continues to attain second fracture, nonetheless compression force increased gradually for the second fracture. This pattern of texture is expressed as jagged force deformation. The cassava fries with high oil and

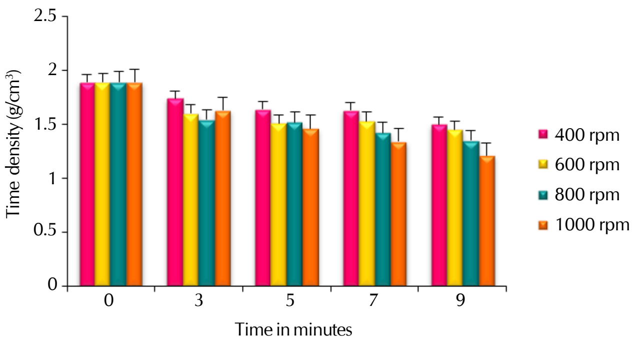
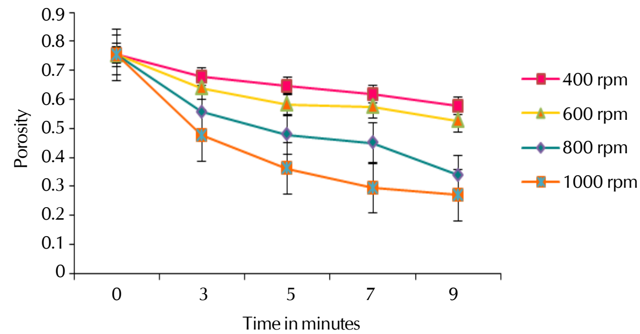


Figure 5: True density of vacuum fried banana chips



6: Porosity of vacuum fried banana chips

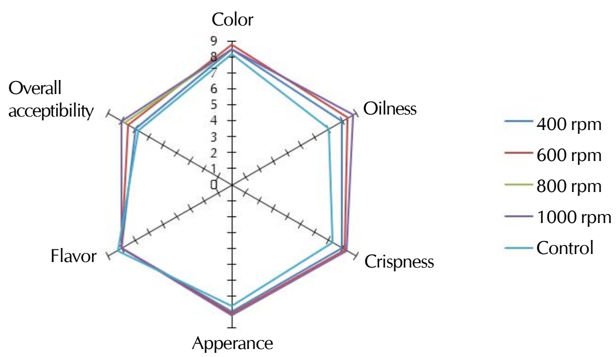


Figure 3.7: Sensory evaluation of vacuum fried banana chips

moisture content showed less crispness than the samples with low oil and moisture content. The samples which are de-oiled at higher centrifuge speed showed low hardness compared with samples centrifuged with low speed. This is due to the retention of oil at lower de-oiling centrifuge speed. The Fig (3.3) below portrays change in hardness value which reflects as increased crispness 1.62 N for product centrifuged at 1000 rpm for all 5, 7 and 9 min. The result can be correlated with oil content of banana chips at 1000 rpm showed no change in its value beyond 5 min of centrifuging. Higher hardness value of 2.98 N was found with control sample, and subtle decrease in hardness value was noted with increase in centrifuging speed.

The cracking force or hardness value is an indicator of crispness degree. The Fig (3.3) illustrates that the degree of crispness suffers with change in centrifuging speed and time. At higher centrifuging speed and time, crispness increased and vice versa. This result agrees with Sothornvit (2011) who reported that higher centrifuge speed of de-oiling showed less hardness value. (Singthong and Thongkaew, 2009) indicates that cell wall weakening occurs as a consequence of cell rupture and breakdown of pectin matters present on the surface of banana which contributes to the textural changes.

Changes in colour values

The colour values are represented in the Table (3.1) exemplifies with higher centrifuging speed and duration yellowness i.e. b^* value was predominantly increased from 34.32 to 46.21, further subtle decrease in a^* value from 9.21 to 7.47 was noted indicating reduced redness. No significant changes ($p < 0.05$) was found between the control and de-oiled samples. The L* value of control chips was 49.83 spiked up to 63.6 with 1000 rpm of centrifuge for 7 min. The changes in colour values can be pronounced as better quality product through de - oiling by centrifuging. This increase is b^* value from 34.3 to 46.21 represents high yellowness in all the experimented banana chips in spite of centrifuging speed and duration. The change in colour can be related with removal of oil content which masks the lightness and yellowness of the fried product. A study conducted by Maity *et al* (2014) on vacuum fried jack fruit with de-oiling showed similar result with higher lightness and yellowness compared to control samples. Dueik *et al* (2010) experimented on vacuum fried carrot chips confessed similar trend of colour values variation.

Changes in bulk density, true density and porosity

The changes in porosity value depend on bulk density and true density of vacuum fried banana chips. The bulk density of the product increased linearly with increase in centrifuging speed and duration compared to control sample. The increase can be apparently understood from the graph Fig.3.4, which show high bulk density value of 0.978 g/cm³ at 1000 rpm for 9 min of centrifuging and the least bulk density value in de – oiled chips was 0.562 g/cm³ at 400 rpm for 3 min.

Kim *et al.*, 2011 evidenced similar trend of change in bulk density of vacuum fried potato chips. The true density gets decreased slightly with increase in de – oiling speed. The true density values were illustrated in the graph Fig.3.5, lower value of 1.21 g/cm³ was observed at 1000 rpm for 9 min, no significant variation was found within the time of de – oiling at 1000 rpm. At lower centrifuging speed of 400, 600 rpm the true density value ranged between 1.74 to 1.35 g/cm³. The trend of decrease in true density and increase in bulk density formulates the porosity value to decrease. A study done by Pan *et al.,* (2015) found similar result on vacuum fried shrimps. This concomitant behaviour of vacuum fried banana chips can be linked to oil content of the product. The Fig. (3.6) illustrates the porosity value of fired banana chips. The low porosity value of 0.56 was noted at high centrifuging speed of de – oiling while high porosity value of 0.75 was observed at lower centrifuge speed. Porosity depends on bulk density and true density. Porosity increases with increase in oil uptake, hence for the de - oiling samples porosity decreased from initial value. The result was in accordance to the previous finding of de-oiled potato chips at different temperatures 120, 130 and 140°C by Carla and Moreira (2011). At high temperature of frying reduced oil absorption letting the porosity value decline to 0.679 from 0.686 was observed in case of vacuum fried potato chips.

Sensory analysis

The Fig 3.7. depicts the sensory evaluation score for the sensory attributes of the vacuum fried banana chips with different centrifuging specification. It was clear from the graph despite of different centrifuging speed and duration, no significant changes was observed in colour, crispness though instrumental measurement exhibited changes with centrifuging parameter. The oiliness attribute showed highest score of 8.5 with highest centrifuging speed of 1000 rpm indicating less oiliness felt by the sensory panellists than control sample with low 6.5 score of oiliness. The product centrifuged at high speed can be considered as best sample in pertaining to sensory evaluation. Findings of Sothornvit (2011) on gum coated high speed centrifuged banana chips evidenced similar result on sensory attributes.

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