

Use of hydrocolloids to improve the quality of vacuum fried jackfruit chips

*Maity, T., Bawa, A. S. and Raju, P. S.

*Fruits and Vegetables Technology Discipline, Defence Food Research Laboratory,
Siddarthanagar, Mysore-570011, Karnataka, India*

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Abstract

The aim of this research was to investigate the influence of hydrocolloid pre-treatment, i.e. pectin, carboxymethyl cellulose (CMC), gum arabic and sodium alginate on the quality of vacuum fried jackfruit (JF) chips. The control JF samples (no hydrocolloid treatment) showed higher absorption of oil whereas the oil absorption was less in the hydrocolloid pre-treated samples. The retention of moisture in samples was found to increase with increase in the concentration of hydrocolloids. However, gum Arabic showed maximum moisture retention followed by sodium alginate, pectin and CMC. All the hydrocolloids except gum Arabic were found to increase the L* value of the JF chips compared to the control sample. Color L* value increased up to 10, 6.5 and 8% in fried chips pre-treated with 2% pectin, CMC and sodium alginate, respectively. The color b* value was also found to increase with increase in concentration of hydrocolloids, whereas color a value was found to decrease. Hydrocolloid pre-treatment increased the force required to break the JF chips. Increase in the concentration of pectin and CMC in pre-treatment showed increase in sensory color attribute of the chips.

Keywords

Vacuum frying
Jackfruit
Hydrocolloids
Oil absorption
Texture
Overall acceptability

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Introduction

Frying is one of the oldest methods of cooking food in oil or fat that provides unique fried flavors and textures to foods. Various chemical changes which occur during frying are starch gelatinization, protein denaturation, surface browning, rapid water evaporation and oil absorption. The specialty of the fried products is their improved palatability and sterile and dry nature with a relatively longer shelf life. However, fried foods are becoming incompatible with the recent consumer trends towards healthier and low fat food products. The increased health awareness of consumers has emphasized the need to limit oil consumption, calories originating from fat, and cholesterol (Bouchon and Pyle, 2004). Excess consumption of oil results in health problems such as coronary heart disease, cancer, diabetes, and hypertension (Saguy and Dana, 2003). Frying process involves high temperature and exposure to oxygen which causes other undesirable effects such as degradation of important nutritional compounds and the generation of toxic molecules in the fried product or in the frying oil (Fillion and Henry, 1998). The above mentioned risks associated with frying have changes the market trends towards healthy, low fat snack food products (Moreira *et al.*, 1999; Maity and Raju, 2013).

Vacuum frying is an alternative to conventional frying and provides significant advantages such as

healthier and high quality fried products (Garayo and Moreira, 2002). It is a deep frying process, which is carried out in a closed system, below the atmospheric pressure preferably lower than 7000 Pa, thereby reducing the boiling point of water substantially and consequently, the frying temperature. The low temperatures employed and minimal exposure to oxygen in the vacuum frying process account for most of its benefits, which include reduction of toxic compound generation (Granda *et al.*, 2004), oil quality protection (Shyu *et al.*, 2005) and nutrient preservation (Da Silva and Moreira, 2008).

Hydrocolloids are high molecular weight polysaccharides used in various food applications such as thickening and gelling agents, stabilizers, and emulsifiers. A variety of foods have been coated with different hydrocolloids to extend the shelf-life of the product due to their desirable barrier properties to gas/moisture and good mechanical characteristics (Hershko and Nussinovitch, 1998; Kampf and Nussinovitch, 2000). Modification of surface properties by the hydrocolloid coatings can contribute to the reduction of the oil uptake during frying (Fiszman and Salvador, 2003). Pectin is used in food industry to improve the dispersion, emulsification, and stability of foods (Sawayama and Kawadata, 1991). Carboxy methyl cellulose (CMC), a synthetic gum is a cellulose derivative and forms a three dimensional network with an ability to link

*Corresponding author.

Email: tanumft@gmail.com

Tel: +91 821 2473290; Fax: +91 821 2473468

water molecules within the system (Andrew, 2004). Alginates are high molecular weight salts of alginic acid with block structure, which gives them the ability to cross-link and bind (Gurkin, 2002). Gum Arabic is an exudate gum which is least viscous of the hydrocolloid gums used for its texturizing capabilities (Williams and Phillips, 2000).

Fruit and vegetables are heat sensitive. Vacuum frying technology can be used to produce fried chips from fruits and vegetables with the necessary degree of dehydration without excessive surface darkening of the chips. Hydrocolloid coating may further improve the quality of the fried product. Jackfruit is an exotic, sweet, fleshy, fibrous, delicious fruit with attractive golden yellow colored ripe bulbs. It is rich source of carbohydrates, minerals, dietary fibers, and vitamins such as ascorbic acid and thiamine (Saxena *et al.*, 2009). Hence the objective of present investigation was to evaluate the effect of various hydrocolloids pre-treatment on the quality of vacuum fried jackfruit chips.

Materials and Methods

Sample preparation

Fully mature whole jackfruits of firm variety, with an average weight of 8–10 kg, devoid of any visible microbial infection or mechanical fissures were procured from the local fruit market at Mysore, India. Fruits were washed with chlorinated water (100 ppm). The edible perianth portion (bulbs) was separated manually by slitting open the fruit using stainless steel knives. The bulbs were given a vertical cut to remove the seed. Each pitted bulb was vertically cut in to uniform slices (4 x 0.5 x 0.5 cm). The pre-cut bulbs were again subjected to sanitary wash in 30 ppm chlorinated water. Pectin and carboxy methyl cellulose (S. D. Fine Chemicals), gum arabic and sodium alginate (Across) were procured as analytical grade chemicals.

Pre-treatment

The cut slices of ripen jackfruit bulbs were subjected to hydrocolloid dip treatment. JF slices (one part) were dipped in different hydrocolloid solutions (three parts) (pectin, CMC, gum arabic and sodium alginate) at 0.5, 1.0, 1.5 and 2.0% levels for 2 hours at room temperature ($28 \pm 2^\circ\text{C}$). After the dip period hydrocolloid solution was drained off and the surface of the treated JF slices was air dried. The JF slices without any hydrocolloid treatment served as the experimental control.

Vacuum frying and experimental conditions

The jackfruit slices were fried in a vacuum fryer equipped with a centrifuge (Vacuum Technologies, Bangalore, India) with a 20 L oil capacity. The working vacuum pressure was kept constant for all the experiments (100 mbar). Fresh vegetable oil was used in all experiments. Once the set temperature of oil was achieved, the samples (treated and untreated) were loaded in the perforated basket. Each batch of 1 Kg JF slices was fried in 20 L of oil. The perforated basket loaded with JF slices was immersed in the hot oil for the prescribed time and was again lifted up from the oil after frying. The fried JF slices within the basket were centrifuged under vacuum at 500 rpm for 8 min to remove the surface oil. Fried JF chips were taken out from the fryer after releasing the vacuum, cooled and packed in polyethylene pouches (70 μm). The samples were stored at 4°C for further analysis.

Moisture content

The moisture content of de-oiled JF chips was determined by gravimetric method in triplicates. Moisture content was calculated by weight loss after drying 3 g of coarsely ground sample in a forced convection oven at 105°C to constant weight (AOAC, 1997).

Oil uptake

Total oil content of coarsely ground JF chips was determined extracting fat with petroleum ether as a solvent by soxhlet extraction apparatus (AOAC, 1997). The procedure was carried out in triplicate and mean value reported.

Color measurement

The color of the JF chips was measured using a tristimulus Colorimeter (Miniscan XE plus, Model No. 45/0-S, Hunter Associates Laboratory, Inc., Reston, VA, USA) which was calibrated using white and black standard ceramic tiles. The measurements were taken using D-65 illuminant and 10° observer. Color was measured in ten JF chips and three readings were taken at different locations on the surface of each JF chip for each experimental condition. The color was expressed in terms of L^* value [lightness, ranging from zero (black) to 100 (white)], a^* value [ranging from +60 (red) to -60 (green)] and b^* value [ranging from +60 (yellow) to -60 (blue)].

Texture

The texture of the fried chips samples was measured in triplicates using a texture analyzer (TAHdi; Stable Micro Systems, London, UK). The JF chips sample was supported using two

parallel edges in order to apply the load centrally. A steel blade of thickness 2.5 mm with flat edge was used to fracture the sample at a constant rate of speed of 10 mm s⁻¹. Pre-test and post-test speeds were set at 1 mm s⁻¹ and 5 mm s⁻¹ respectively. The highest value achieved upon fracturing the sample in the plot was used as the resistance to breakage (Force, N). The data obtained from texture profile analysis was used to determine the crispness values.

Sensory evaluation

Fried jackfruit chips were served to a semi-trained panel of twenty members for sensory evaluation in terms of color, crispiness, oiliness, flavor and overall acceptability using a nine point hedonic scale for likeness (Larmond, 1977). Panelists were scientific staffs of the laboratory who were trained in the use of attributing rating scale for the characteristics examined. The scores were assigned from extremely liked (9) to disliked extremely (1).

Statistical analysis

The results obtained from both physico-chemical analysis and sensory evaluations were subjected to a completely randomized analysis of variance (ANOVA) at $P < 0.05$ and means were separated by Duncan's multiple range tests using Statistica 7 software (Stat Soft, Tulsa, Oklahoma, USA).

Results and Discussion

Moisture loss in fried JF chips

The moisture content of the vacuum fried JF chips was significantly ($P < 0.05$) affected by hydrocolloid treatment (pectin, CMC, gum Arabic and sodium alginate) as well as hydrocolloid concentration (0-2%) (Figure 1). Moisture content in the control (without any hydrocolloid treatment) JF chips was found to be 3.24%. The retention of moisture in samples was found to increase with increase in the concentration of hydrocolloids irrespective of the hydrocolloid pre-treatment. However, gum Arabic showed maximum moisture retention followed by sodium alginate, pectin and CMC. Singthong and Thongkaew (2009) also reported similar behavior of hydrocolloids in retaining moisture in fried banana chips with alginate showing maximum moisture content followed by CMC and pectin. However, effectiveness of gum Arabic has not been checked in their study. The increase in moisture content in the hydrocolloid pre-treated samples might be due to the property of hydrocolloids to bind water and prevent excessive moisture loss during frying. The moisture content of pectin, CMC, gum Arabic and sodium

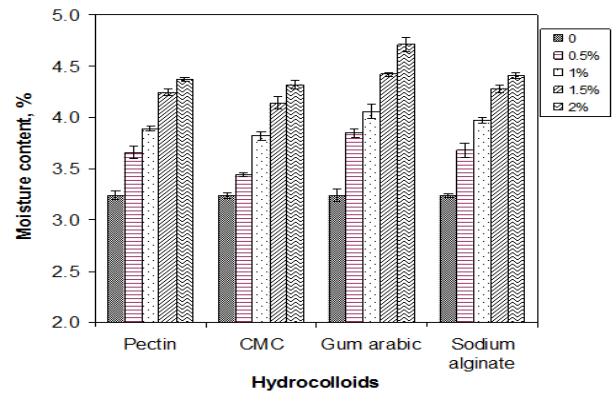


Figure 1. Effect of hydrocolloid pre-treatment on moisture content of vacuum fried JF chips

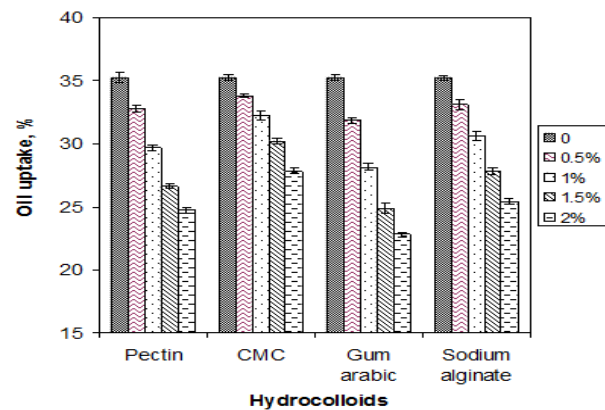


Figure 2. Effect of hydrocolloid pre-treatment on oil absorption of vacuum fried JF chips

alginate pre-treated JF chips ranged from 3.66 to 4.37, 3.45 to 3.32, 3.85 to 4.71 and 3.68 to 4.41, respectively. The difference in retention in moisture content by the hydrocolloids may be attributed to their difference in water holding properties (Maity *et al.*, 2013). Though significant increase in moisture content was observed in the hydrocolloid pre-treated JF chips, it was not high enough to affect the shelf-stability of the chips. Gum Arabic pre-treatment (2.0%) achieved maximum moisture content in the vacuum fried JF chips. Hydrocolloids have also been shown effectiveness in retaining moisture content in deep-fat fried carrot slices (Akdeniz *et al.*, 2006) and in vacuum fried green banana chips (Sothornvit *et al.*, 2011). Akdeniz *et al.* (2006) also explained that the gum coating provides effective moisture retention due to a strong interaction of hydrogen bonds between water molecules of the deep-fat-fried samples.

Oil uptake in vacuum fried JF chips

Moisture removal by evaporation during a frying process makes void spaces within the food which become filled with oils, thus increasing the oil content of fried foods. A maximum oil uptake of 35.24%

Table 1 Effect of hydrocolloid pre-treatment on the Color profile of vacuum fried JF chips

| | Concentration (%) | L* | a* | b* |
|-----------------|-------------------|---------------------------|--------------------------|---------------------------|
| Control | 0 | 56.34 ± 0.05 ^b | 6.75 ± 0.02 ^c | 38.36 ± 0.07 ^a |
| Pectin | 0.5 | 57.42 ± 0.03 ^b | 6.19 ± 0.02 ^b | 43.17 ± 0.05 ^a |
| | 1 | 59.78 ± 0.02 ^c | 5.93 ± 0.03 ^b | 48.39 ± 0.03 ^b |
| | 1.5 | 60.25 ± 0.07 ^c | 5.84 ± 0.04 ^b | 52.16 ± 0.02 ^b |
| | 2 | 62.82 ± 0.04 ^c | 5.61 ± 0.04 ^b | 56.23 ± 0.05 ^b |
| | 0.5 | 57.12 ± 0.04 ^b | 6.81 ± 0.03 ^c | 42.36 ± 0.03 ^a |
| CMC | 1 | 58.24 ± 0.03 ^b | 6.74 ± 0.02 ^c | 46.78 ± 0.07 ^b |
| | 1.5 | 59.12 ± 0.05 ^c | 6.53 ± 0.02 ^c | 48.45 ± 0.05 ^b |
| | 2 | 60.23 ± 0.02 ^c | 6.49 ± 0.04 ^c | 51.83 ± 0.02 ^b |
| | 0.5 | 49.71 ± 0.07 ^b | 6.35 ± 0.02 ^c | 44.22 ± 0.04 ^a |
| Gum arabic | 1 | 39.45 ± 0.04 ^a | 6.14 ± 0.07 ^b | 50.13 ± 0.03 ^b |
| | 1.5 | 31.83 ± 0.03 ^a | 5.65 ± 0.04 ^b | 53.40 ± 0.07 ^b |
| | 2 | 28.47 ± 0.03 ^a | 5.01 ± 0.02 ^a | 59.87 ± 0.02 ^c |
| | 0.5 | 57.16 ± 0.02 ^b | 6.02 ± 0.03 ^b | 42.52 ± 0.05 ^a |
| Sodium alginate | 1 | 58.53 ± 0.05 ^b | 5.27 ± 0.07 ^a | 44.45 ± 0.07 ^a |
| | 1.5 | 59.94 ± 0.05 ^c | 5.08 ± 0.02 ^a | 49.83 ± 0.02 ^b |
| | 2 | 61.22 ± 0.02 ^c | 4.78 ± 0.03 ^a | 55.94 ± 0.03 ^b |

Values with different superscript in the same column differ significantly. (P<0.05)

was observed in the control JF chips sample. Effect of different hydrocolloid pre-treatments on the oil uptake in vacuum fried chips are predicted in Figure 2. All the hydrocolloids were found to decrease the oil uptake significantly (P < 0.05). The oil uptake was also found to be decreased in JF chips with higher concentration of hydrocolloids. Gum Arabic was more effective in decreasing the oil uptake followed by pectin, CMC and sodium alginate, respectively. Pre-treatment of JF slices in 2.0% gum Arabic solution showed maximum reduction in oil uptake. It could reduce the oil uptake up to 35.3%. The oil uptake during vacuum frying in gum arabic pre-treated JF samples were found to be 31.84, 28.16, 24.88 and 22.8% at 0.5, 1.0, 1.5 and 2.0%, respectively. Oil uptake in pectin pre-treated samples at 0.5, 1.0, 1.5 and 2.0% were 32.8, 29.68, 26.64 and 24.72%, respectively. Oil uptake associated with 0.5, 1.0, 1.5 and 2.0% CMC and alginate pre-treatment were also significant (P < 0.05) over the experimental control with values 33.84, 32.24, 30.24 and 27.84% and 33.14, 30.60, 27.84 and 25.44%, respectively. The oil absorption in fried foods is a surface phenomenon. The mechanism of oil absorption during frying occurs in the cooling phase after the food has been completely fried. As a consequence of decreased internal pressure during cooling the oil adhered on the surface is sucked into the voids (Dana and Saguy, 2006; Maity and Raju, 2013). In the present study the voids were not vacant due to the hydrocolloid pre-treatment for absorption of the oil, thus the oil uptake was reduced significantly (P < 0.05) in the pre-treated JF chips. Another reason for reduced oil uptake in pre-treated samples could be the amount of moisture content in JF chips as a correlation between lower oil uptake and higher moisture content was also observed in JF chips, since oil absorption

happens as the moisture is removed from the food during the frying process (Saguy and Pinthus, 1995; Salvador *et al.*, 2008). Akdeniz *et al.* (2006) also found similar relationship between moisture loss and oil absorption in deep fat fried carrot slices coated with hydrocolloids. Hydrocolloids have been proved to reduce the oil uptake during the frying process by several researchers. Sothornvit *et al.* (2011) showed very less oil uptake in fried banana chips treated with guar gum and indicated that guar gum could substitute the use of high speed centrifugation for de-oiling during vacuum frying process. Kim *et al.* (2011) also showed effectiveness of gellan and guar gum in reducing oil uptake during frying of potato chips.

Color of vacuum fried JF chips

Color of fried chips is an important attribute which significantly affects the consumer's perception. The color of the JF chips were assessed in terms of lightness (L*), redness (a*) and yellowness (b*) to estimate the color changes during vacuum frying. Table 1 shows the effect of hydrocolloid pre-treatment on the color co-ordinates of vacuum fried JF chips. All the hydrocolloids except gum Arabic were found to increase the L* value of the JF chips compared to the control sample. The effect of increased hydrocolloid concentration on color was found to be most pronounced with respect to pectin followed by CMC and sodium alginate, respectively. Color L* value was also found to increase with the increase in the concentration of different hydrocolloids. Color L* value increased up to 10, 6.5 and 8% in fried chips pre-treated with 2% pectin, CMC and sodium alginate, respectively. Gum Arabic treatment decreased the L* value with higher concentration showing less L* value in JF chips. The original light brown colour

Table 2 Effect of hydrocolloid pre-treatment on breaking force of vacuum fried JF chips

| Concentration (%) | Pectin | CMC | Gum arabic | Sodium alginate |
|-------------------|------------------------|------------------------|------------------------|------------------------|
| 0 | 3.21±0.04 ^a | 3.21±0.02 ^a | 3.21±0.08 ^a | 3.21±0.03 ^a |
| 0.5 | 3.47±0.02 ^b | 3.45±0.02 ^b | 3.78±0.05 ^b | 3.57±0.02 ^b |
| 1 | 3.58±0.03 ^b | 3.66±0.05 ^b | 4.05±0.04 ^b | 3.88±0.03 ^b |
| 1.5 | 4.17±0.05 ^b | 4.37±0.04 ^c | 4.72±0.03 ^c | 4.54±0.04 ^c |
| 2 | 4.35±0.06 ^c | 4.59±0.06 ^c | 5.14±0.02 ^d | 4.87±0.03 ^c |

Values with different superscript differ significantly. (P<0.05)

of the gum Arabic might be responsible for the decreased lightness of JF chips. Increase in lightness was accompanied with increase in yellowness as indicated by increase in color b* value. The control JF chips showed a value of 38.36 for color b* coordinate which increased to 56.23, 51.83, 59.87 and 55.94 in pectin, CMC, gum Arabic and sodium alginate pre-treated (2%) chips, respectively. Sothornvit *et al.* (2011) reported similar behavior of color coordinates in banana chips coated with hydrocolloid. They found increase in lightness as well as yellowness in banana chips coated with xanthan or guar gum. However, Singthong and Thongkaew (2011) reported decrease in lightness in the fried banana chips pre-treated with pectin and CMC. Whereas, Garcia *et al.* (2002) reported no significant changes in the color of potato chips applied with an edible coating. The difference in the behavior of color values of different chips upon hydrocolloid treatment might be related to the nature of the product, modification of surface property of the tissue or differences in the frying process. The color a* value which determines the extent of redness in the sample was found to decrease in the JF chips due to hydrocolloid treatment. Though increasing the hydrocolloid concentration was found to decrease the color a* value of the JF chips, the decrease was not significant (P>0.05) in JF chips pre-treated with pectin and CMC. Change in color a* value of fried banana chips has also been reported to be non-significant due to hydrocolloid coatings (Sothornvit *et al.*, 2011). The change in color a* value in gum Arabic and alginate treated sample at highest concentration (2.0%) was found to be 25.78 and 29.19%, respectively from the control sample.

Texture of vacuum fried JF chips

Crispy texture of fried food products determines the eating quality and consumer acceptability. Crispness of the jackfruit chips untreated and pre-treated with hydrocolloids was measured as the force required to break the chips on a texture analyzer. In fried products lower breaking force indicates higher crispy texture. Different hydrocolloids affected the jackfruit slice surface differently to give a final fried

crisp texture (Table 2). Hydrocolloid pre-treated JF chips showed a higher breaking force than the control. At the highest concentration level (2%), the breaking force increased to 36, 43, 60 and 52% from the original in pectin, CMC, gum arabic and sodium alginate pre-treated samples, respectively. The lower breaking force and higher crispness in the untreated JF chips may be due to the presence of air cells which were filled with the hydrocolloids during pre-treatment in the treated JF chips. Pre-treated samples formed a rigid, resistant film on the surface of the JF slices that protected the structure during vacuum frying, unlike the untreated control JF chips (Chang *et al.*, 1993; Khalil, 1999). Gum Arabic pre-treated JF chips showed maximum breaking force followed by sodium alginate, CMC and pectin pre-treated JF chips. The breaking force was also found to increase with increase of the hydrocolloid concentration in the pre-treatment. This may be due to provided protection by hydrocolloids against mechanical damage. Similar protection against mechanical damage has been observed by Sothornvit (2011) in vacuum fried banana chips. Our results are in agreement with the results reported by Singthong and Thongkaew (2009). They also found increase in the hardness (lower crispness) in deep-fat-fried banana chips coated with alginate, carboxymethyl cellulose and pectin compared with control samples.

Sensory acceptability of vacuum fried JF chips

The sensory acceptability of JF chips in terms of color, flavor, texture, taste and overall acceptability was found to be significantly (P<0.05) affected by hydrocolloid pre-treatment (Table 3). The color of pectin and CMC treated samples recorded higher scores than the gum Arabic and alginate treated JF chips. Increase in the concentration of pectin and CMC in pre-treatment showed increase in sensory color attribute of the chips. This may be due to the brightness attained by the samples during hydrocolloid pre-treatment as shown elsewhere by increase in L* values of the samples. Increase in pectin and CMC concentrations from 0.5 to 2.0% was accompanied by increase in the other sensory parameters also such as flavour, texture, taste and OAA as compared to the control. Gum Arabic and alginate pre-treatments affected the sensory quality differently. Pre-treatment of JF chips with gum Arabic and alginate reduced the taste and flavor of JF chips. This may be due to the tendency of gums to impart thickening. As the concentration of these gums increased the sensory flavor and taste scores decreased. However, the decrease was not significant (P>0.05) in alginate treated JF chips. Texture of JF

Table 3 Effect of hydrocolloid pre-treatment on Sensory acceptability of vacuum fried JF chips

| | Concentration (%) | Color | Flavor | Texture | Taste | Overall Acceptability |
|-----------------|-------------------|--------------------------|--------------------------|--------------------------|--------------------------|---------------------------|
| Control | 0 | 8.00 ± 0.06 ^b | 8.05 ± 0.06 ^a | 8.00 ± 0.06 ^b | 8.10 ± 0.04 ^a | 8.10 ± 0.06 ^b |
| Pectin | 0.5 | 8.15 ± 0.06 ^b | 8.08 ± 0.09 ^a | 8.21 ± 0.04 ^b | 8.10 ± 0.05 ^a | 8.18 ± 0.05 ^b |
| | 1 | 8.32 ± 0.09 ^a | 8.14 ± 0.04 ^a | 8.42 ± 0.05 ^a | 8.17 ± 0.04 ^a | 8.36 ± 0.05 ^a |
| | 1.5 | 8.45 ± 0.05 ^a | 8.24 ± 0.04 ^a | 8.63 ± 0.04 ^a | 8.38 ± 0.08 ^a | 8.50 ± 0.05 ^a |
| CMC | 2 | 8.58 ± 0.09 ^a | 8.49 ± 0.04 ^a | 8.74 ± 0.06 ^a | 8.31 ± 0.04 ^a | 8.65 ± 0.06 ^a |
| | 0.5 | 8.10 ± 0.04 ^b | 8.00 ± 0.05 ^a | 8.05 ± 0.09 ^b | 8.12 ± 0.05 ^a | 8.10 ± 0.04 ^b |
| | 1 | 8.26 ± 0.06 ^a | 8.23 ± 0.09 ^a | 8.38 ± 0.06 ^a | 8.26 ± 0.05 ^a | 8.35 ± 0.06 ^a |
| Gum Arabic | 1.5 | 8.38 ± 0.04 ^a | 8.26 ± 0.04 ^a | 8.51 ± 0.04 ^a | 8.40 ± 0.04 ^a | 8.42 ± 0.09 ^a |
| | 2 | 8.45 ± 0.04 ^a | 8.02 ± 0.09 ^a | 8.31 ± 0.09 ^a | 8.24 ± 0.05 ^a | 8.26 ± 0.05 ^{ab} |
| | 0.5 | 7.84 ± 0.09 ^b | 7.15 ± 0.04 ^b | 8.10 ± 0.04 ^b | 7.55 ± 0.06 ^b | 7.33 ± 0.04 ^b |
| Sodium Alginate | 1 | 7.55 ± 0.05 ^b | 6.98 ± 0.09 ^b | 7.75 ± 0.09 ^b | 6.87 ± 0.04 ^b | 7.04 ± 0.06 ^b |
| | 1.5 | 6.87 ± 0.05 ^c | 6.81 ± 0.05 ^b | 7.26 ± 0.06 ^c | 6.19 ± 0.04 ^c | 6.86 ± 0.09 ^c |
| | 2 | 6.58 ± 0.06 ^c | 6.64 ± 0.07 ^b | 7.05 ± 0.06 ^c | 5.91 ± 0.06 ^d | 6.75 ± 0.09 ^c |
| Sodium Alginate | 0.5 | 7.95 ± 0.09 ^b | 7.84 ± 0.04 ^b | 8.05 ± 0.06 ^b | 7.26 ± 0.05 ^b | 7.50 ± 0.05 ^b |
| | 1 | 7.26 ± 0.06 ^c | 7.12 ± 0.08 ^b | 7.55 ± 0.05 ^c | 7.20 ± 0.05 ^b | 7.34 ± 0.04 ^b |
| | 1.5 | 6.98 ± 0.05 ^c | 6.40 ± 0.06 ^b | 7.18 ± 0.04 ^c | 7.14 ± 0.04 ^b | 7.05 ± 0.06 ^b |
| | 2 | 6.69 ± 0.04 ^c | 6.58 ± 0.09 ^b | 6.95 ± 0.05 ^d | 7.08 ± 0.06 ^b | 6.88 ± 0.05 ^c |

Values with different superscript in the same column differ significantly. (P<0.05)

chips was found to increase in all the hydrocolloid pre-treated samples. The hydrocolloid pre-treatment provided more mechanical strength to the fruit tissue which in turn improved structural integrity and resulted in higher sensory scores. Different concentrations of hydrocolloids exhibited different affects on OAA. The overall acceptability of JF chips without any hydrocolloid treatment was found to be 8.1 which increased due to pectin and CMC treatment. This could be due to lesser oil uptake by the hydrocolloid pretreated samples during frying. The decrease in OAA associated with increased concentration of gum Arabic and alginate may be due to the thickening affect and darker color of the JF chips. Alimi *et al.* (2014) also showed significant (P<0.05) decrease in sensory acceptability of fried yam chips with increase in hydrocolloid (xanthan gum, gum tragacanth and CMC) concentration from 0.5 to 1.5%. Our results of sensory evaluation are also in accordance with the results reported by Singthong and Thongkaew (2009). They reported decrease in sensory acceptability of banana chips treated with alginate and found highest overall acceptability of pectin treated banana chips compared to CMC and alginate. Contrary to our results, Sothornvit (2011) reported no significant differences on sensory attributes of hydrocolloid treated banana chips as compared to the untreated banana chips.

Conclusion

Vacuum frying has a significant strategic importance for future fried food manufacturing. The results confirmed that the use of hydrocolloids helped in reducing the oil absorption of vacuum fried Jackfruit chips. The oil absorption had a reciprocal relationship with the moisture content retained in the Jackfruit chips. Gum Arabic pre-treatment was more effective in reducing the oil uptake. The

results showed that pectin and CMC pre-treatments increased the sensory perceptions of JF chips. It can be concluded that hydrocolloids pre-treatment could be used to decrease the oil absorption while maintaining the high quality of the fried fruit chips which would benefit the consumers, adding value to the snack market as a healthy food product.

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