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EFFCET OF NANOEDIBLE COATING OF FRENCH FRIED POTATOES AND OIL UP TAKE REDUCTION

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ABSTRACT

The effect of nanoparticles of chitosan and carrageenan as an active coating on oil reduction of potato strips during frying was investigated using different concentrations of chitosan and carrageenan. The rheological properties of edible coating materials showed non –Newtonian pseudo plasticbehavior. The results illustrated that nano particle of carrageenan (24nm) reduced oil absorption from12% to 4.93%at 170°C and moisture content was (54.83%).

I INTRODUCTION

The potato products such as French fries, chips, balls, etc. are also fried products which absorb a high amount of oil. These products though taste right, pose health problems due to high calorie and cholesterol intake. [1]

An edible coatingisathinlayerof edible material formedas a coating on a food product, [2]While an edible film is a preformed thin layer, made of the edible material, which can be placed on or between food components [3,4].

The main differencebetween these two food systems are that the edible coating is appliedin liquid form on the food. This is usually done by immersing the product in the solution of edible material, the edible film is first molded assolid sheets, then applied as a wrapping for food products [5].Their growing application is attributable toreduction of moisture loss, adverse chemical reactions [6,7]. Spoilage, and microbial contamination [8].Additionally, they can be used for controlled release of food additives [9]. Edible coatings are also effective as a post-harvest treatment to preserve fruit quality [10].

Rheology is the branchofsciencedealingwiththe flowanddeformation of materials. Rheologicalinstrumentation and rheological measurementshave become essential tools in theanalytical laboratories for characterizing componentmaterials and final products, monitoring process conditions, as well as predicting product performance and consumer acceptance[11].

The flow behavior of the edible coatingsolutions needs to be studied since the viscosity ofthe film forming solution is key to controlling thedesirable thickness of the coating [12].Theviscosity of the coating solutions is also important for decreasing the dewetting process which prevents the creation of a continuous layer around food, making in necessary that the magnitude of the viscousforces be greater than that of the interfacial ones[13].Edible films are made of various materials, are formed by different processes, and have various properties. Edible film formers include polysaccharides, proteins, and lipids. Polysaccharides may include cellulosederivatives; starches and their derivatives; seaweed extracts such as carrageenan and alginates; pectin andchitosan. Protein film formers include collagen, gelatin, whey protein, corn, zein, soy protein, and wheat gluten. Polysaccharide and Protein film materials are characterized by high moisture permeability, low oxygen and lipidpermeability at lower relative humidities, as well as a compromised barrier and mechanical properties at high relative humidities [14].

Deep-fat frying is a widely used method for preparing foods with an attractive and tasty surface. The soft and moist interior along with the porous outer crispy crustprovides increased palatability to foods [15].

One of the critical quality attributes of deep fat fried products is the amount of oil content in these products. Fried food with low-fat content, can hard texture edible coating have long been known to protect perishable food, from deterioration by retarding dehydration suppressing respiration, improving texture quality, helping to retain volatile flavor compounds and reducing microbial growth. Another application of edible films of the coating is a barrier to lipid absorption by food during deep fat frying. Oil uptake in fried foods has become a health concern, high consumption of lipids been related to obesity and other health problem such as coronary heart disease [16].

The aim of the work is to study the effect of different particle size of nanoparticle solutions as coating materialcompared with the various concentrations of chitosan and carrageenan solution to use thecoating as mentioned above materials to reduce fatabsorption during the frying process. Also, the rheologicalproperties of the corresponding edible coating mixtures have been studied with the aim ofelucidating the phase behavior and measuring the viscoelastic properties of the mixtures on the way to the filmformation.

II MATERIAL AND METHOD

2.1. Materials

Chitosan and Sodium tripolyphosphate (TPP) were purchased from Acemtic Company. Carrageenan was purchased from Mefad Company.

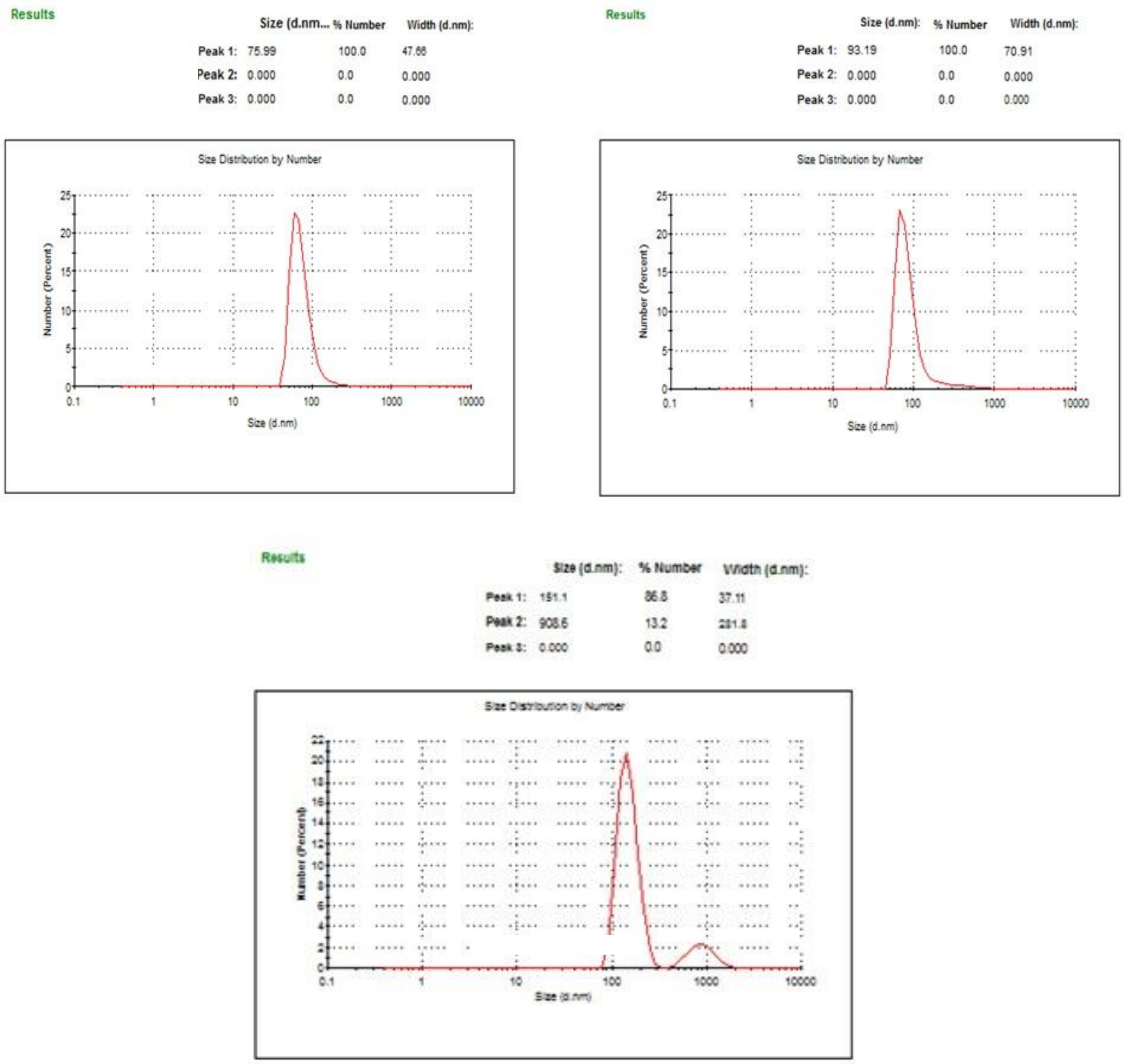
2.2. Methods

2.2.1. Preparation of potato strips

Potato tubers were washed, hand-peeled and cut with a manual operated potato-cutting device into an 8×8×60 mm strips, then rinsed in tap water.

2.2.2. Preparation of Chitosan nanoparticles

Chitosan nanoparticles were prepared according to [17]. Chitosan was dissolved in (1%) acetic acid with stirring until to be completely soluble. TheTPP solution was added to chitosan solution drops with different chitosan: TPP ratios (1:1, 2:1 and 3:1).



Results

	Size (d.nm...	% Number	Width (d.nm):
Peak 1:	75.99	100.0	47.66
Peak 2:	0.000	0.0	0.000
Peak 3:	0.000	0.0	0.000

Results

	Size (d.nm):	% Number	Width (d.nm):
Peak 1:	93.19	100.0	70.91
Peak 2:	0.000	0.0	0.000
Peak 3:	0.000	0.0	0.000

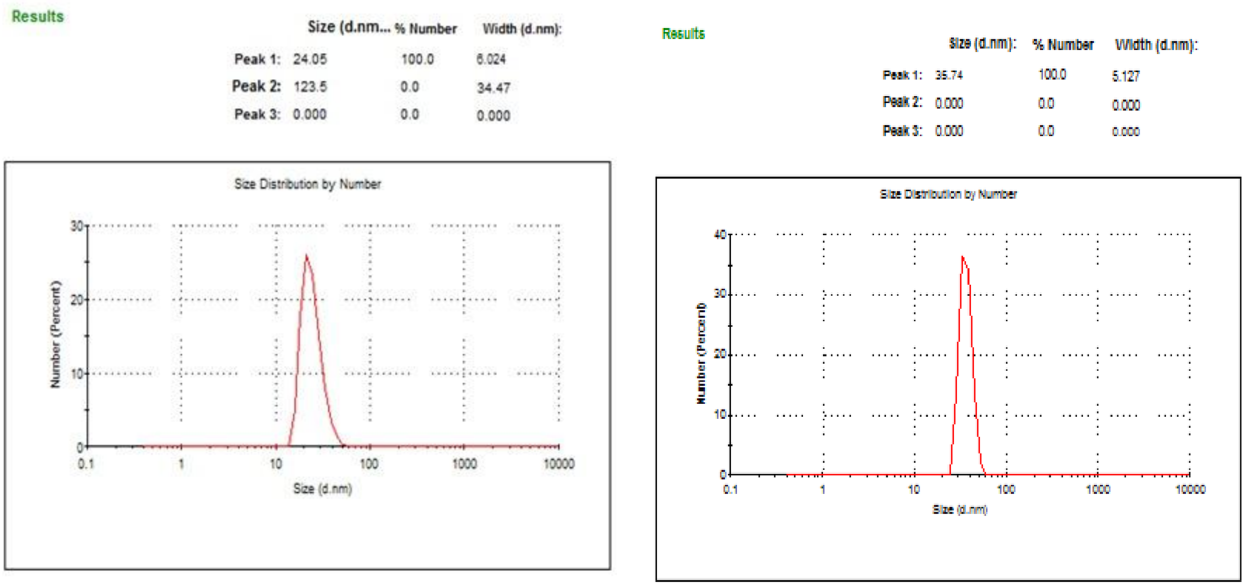
Results

	Size (d.nm):	% Number	Width (d.nm):
Peak 1:	151.1	86.8	37.11
Peak 2:	908.6	13.2	281.8
Peak 3:	0.000	0.0	0.000

Fig.(1) Distribution particle size of nano chitosan

2.2.3. Preparation of nano Carrageenan particles

Carrageenan nanoparticles were prepared by dissolving carrageenan in distilled water withstirring at 70°C.TheTPP solution was added to carrageenan solution drop wise at carrageenan: TPP ratio (1:1).



Results

	Size (d.nm...	% Number	Width (d.nm):
Peak 1:	24.05	100.0	6.024
Peak 2:	123.5	0.0	34.47
Peak 3:	0.000	0.0	0.000

Results

	Size (d.nm):	% Number	Width (d.nm):
Peak 1:	35.74	100.0	5.127
Peak 2:	0.000	0.0	0.000
Peak 3:	0.000	0.0	0.000

Fig. (2)Distribution Particle size of carrageenan

2.2.4. Rheological Properties of edible coating solution

Rheological properties (viscosity, shear stress, shear rate) of different concentrations of nano-chitosan and nano-carrageenan solutions were measured using Brookfield Engineering Labs DVIIIUltra Rheometer. The samples were placed in a small sample adapter at a constant temperature using thermostatic water bath. The viscometer was operated between 10 and 100 rpm, and the results of shear stress, shear rate, and viscosity data were obtained directly from the instrument; the SC4-21 spindle was selected for the measurement.

2.2.5. Preparation of potato strips before frying:

Three lots of potato pieces were separately immersedat room temperature for two minutes in coating solutions of a) different concentrations of chitosan, b) various concentrations of carrageenan, c) different particle size solution of nano-chitosan and d) different particle size of nano carrageenan. Thesamples were removed and then blotted withfilter paper to remove surface moisture. Sun flower oil was used as a frying medium, an amini fryer with 1 L capacity was used for fryingoperation. The samples were immersed in thehot oil (170 and 190˚C) and fried for 4-5 min. Fried samples were removed from the unit and theexcess surface oil absorbed with filter paper. Samples were then allowed to cool to room temperature for 5 min before oil contentanalysis was done. The oil and moisture contents were determined using Soxhlet extraction method and ovendrying method at 105˚C until constant weightrespectively according to the guidelinesproposed by[18].

2.2.6. Analysis of the Coating Material

Yield parameters were determined by measuring the mass of the raw potato strips (X), the mass of the coated potato strips before frying (Y) and the mass of the coated potato strips after frying(Z). The yield parameters were calculated using the following equations [19].

$$Adhesiondegree = \frac{Y-X}{Y} \times 100 \qquad (1)$$

$$Yield = \frac{Z}{X} \times 100 \qquad (2)$$

$$Fryingloss = \frac{Y-Z}{Y} \times 100 \qquad (3)$$

III RESULTS AND DISCUSSION

3.1.Rheological properties of chitosan and carrageenan solution

Rheological properties of chitosan and carrageenan solution were measured for the prepared blends to investigate the flow behavior of blends which is an important factor for food coating materials. Accurate rheological characterization is of critical importance regard in terms of commercial processibility, physiological activity product design,…etc. [20].

Figure(3) shows the effect of shear rate on the apparent viscosity of different concentrations of chitosan solution. The results indicated that by increasing the concentration of chitosan, the apparent viscosity increased at all shear rates studied. More pseudo plastic is observed with increasing chitosan concentration, this can be explained concerning the degree of chain entanglements, as polymer concentration is increased, the freedom of movement of the individual chains becomes restricted due to the correspondingly increased number of complications.

The shear thinning region curve can be expressed by the following power low equation.

$\mu = K\gamma^{n-1}$

Where μ is the apparent viscosity (Pa.s), K is the consistency index, γ is the shear rate (1/ s), n is the flow behavior index.

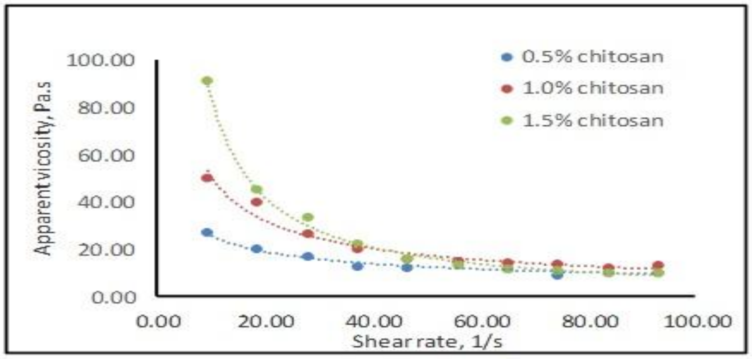


Fig.(3) Effect of shear rate on apparent viscosity of chitosan solution

Figure (4) illustrates the effect of shear rate on apparentviscosityof different concentration of carrageenan solution (0.5, 1 and 1.5%).The results indicated that apparentviscositydecreasedas shear rate increased for all concentration studied, as previously discussedby[21]. Theshearing behavior of carrageenan solution was found to be fitted by power law equation.

The low concentration of carrageenan solution show low pseudo plasticity since the rate of disentanglements is higher than that entanglement.

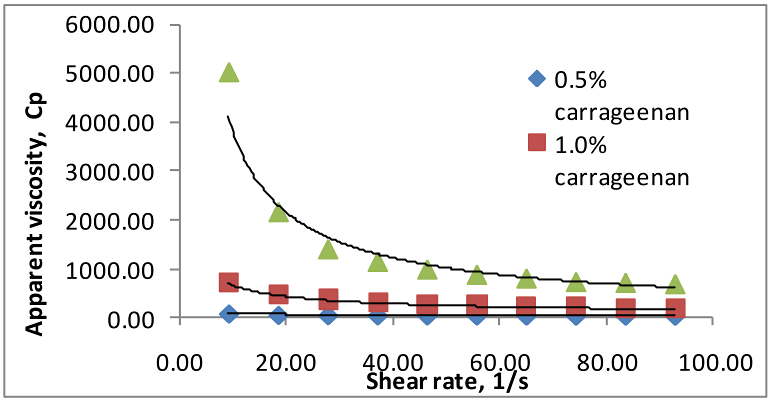


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Fig.(4) Effect of shear rate on apparent viscosity of Carrageenan solution

3.2. Rheological properties of nanoparticle suspended solution.

Figure (5) displays the relation between shear rate and apparent viscosity for chitosan and corresponding chitosan/tripolyphosphate solutions. The results indicate that the suspensions exhibited non-Newtonian pseudo plastic behavior since the viscosity decreased with increasing the shear rate. These results are following the findings of[22].Apparent viscosity decreased as particle size of nano-chitosan increased, and this may be due to that the larger the particle size, the higher will be the resistance offered for flow of liquid and hence the higher will be the viscosity and vice versa[23].

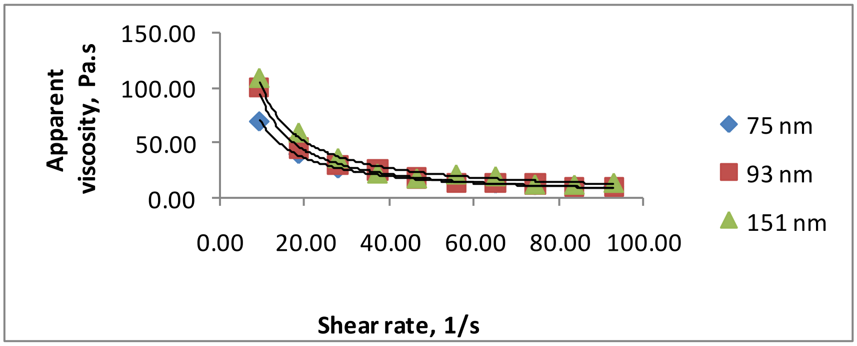

Fig.(5) Effect of shear rate on apparent viscosity of chitosan nanoparticles

Figure(6) shows the effect of shear rate on apparent viscosity of nano-carrageenan suspended solution. The results indicated that apparent viscosity increased as increasing the particle size of nano-carrageenan and decreased as shear rate increased.

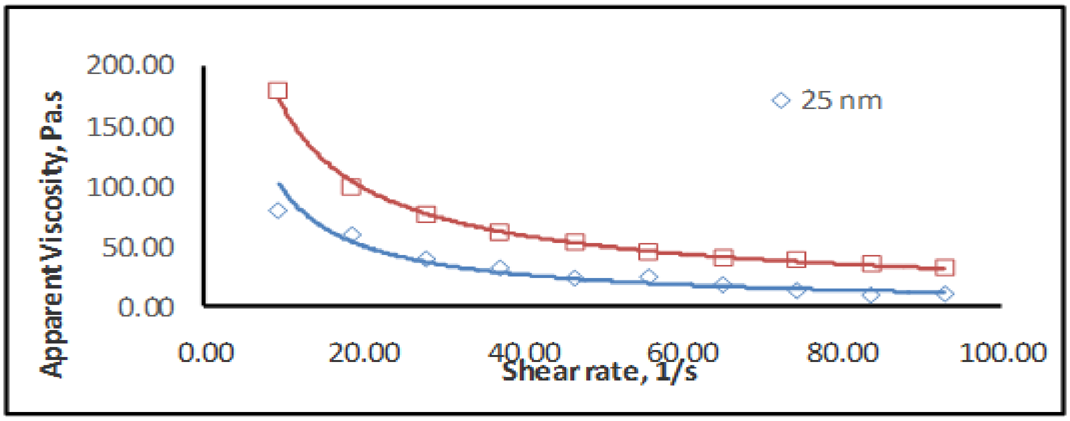

Fig. (6) Effect of shear rate on apparent viscosity of carrageenan nanoparticles

3.3. Effect of edible coating on adhesion degree, yield and frying loss

Table (1) shows the effect of different edible coatings on adhesion degree, which was determined using equation(1).The results obtained are listed in Table (1). It showed that the highest degree for adhesion (32.966 %) was foundfor potato strips coated with nano-carrageenan (24nm), while the lowest adhesion degree was recorded for samples coated with 0.5% chitosan (1.379%).

The effect of different edible coatings on yield percent was also studied and determined using equation (2) and given in Table (1).The results showed that the highest yield % (97,227%) was found for samples coated with nano carrageenan(24nm) with ,whereas the lowest yield percent was recorded for samples coated with nano chitosan (150nm).

The effect of different edible coatings on frying loss was determined using equation (3). The results illustrated that the highest frying loss (15.79%) was found for samples coated with 0.5% chitosan and the lowest frying loss was recorded(9.45%) for samples coated with nano carrageenan(24nm).

3.4. Effect of edible coating on moisture content

The edible coated samples retained more moisture in the surface layer than control samples. Table (1) shows the moisture content of the sample after final frying. The results indicated that using edible coating for frying of potato strips caused increasing in moisture contents of the products. Nano-carrageenan (24nm) showed that the best results with respect to the edible efficiency coating in increasing moisture content during frying (170°C) process of potato strips. Chitosan (0.5%) had lower moisture content, while it increased as concentration of chitosan increased. Moisture content decreased as particle size of nanochitosan increased, this may be due to that coating was proportional to the increase in concentration of edible coating, indicating greater moisture retention by thicker films[21].The results illustrated that moisture content increased with increasing frying temperature, This may be due to that increasing the frying temperature made harder and more durable coating, which could be increased the resistance of products against mobility of the materials and improved a surface diffusivity. In the present study increased frying temperature retains more moisture, [23].

3.5. Effect of edible coating on oil absorption

The reduction of oil content of coated and uncoated potato strips are shown in table (1). A reduction of oil up take was observed for deep fat fried coated potato strips samples compared to control samples. The surface layer coated sample absorbed lessoil compared to the control sample, edible films as gel-forming compounds forms a fine net structure which prevents the oil migration in the potato tissue during the fryingprocess according to the type of film used[24].The resultsshow that fat rate for potato strips coated with suspended nanoparticle solutions in comparison with control samples and that which causes the oil to diffuse in a counterdirection (from inside to outside of the food), this is in agreement with (Diaze, et al., 1999) Among all edible coating tested, nano-carrageenan (24nm) and nano-chitosan (75nm) provided that the lowest fat contentare 4.933 and 5.09%, respectively. This may be due to the fact that potato strips coated with nanoparticles suspensions causes the oil to diffuse in counter direction from inside to outside of the food [25,26].

Table1. The effect of coating materials on the values of adhesion degree, yield, frying loss, Moisture, and Fat percent

Sample	Adhesion degree, %	Yield, %	Frying loss	Fat%		Moisture content	
				170ºC	190ºC	170°C	190°C
Control	---	---	---	13.23	12.23	52	53
0.5% Chitosan	1.379	85.384	15.793	8.6	10.928	53.846	55.1
1% Chitosan	6.962	91.496	14.873	7.133	8.45	57.213	55.22
1.5% Chitosan	7.82	95.685	10.068	7.4	7.352	58.745	58.46
75nm nano-chitosan	25.376	86.704	11.561	5.09	5.07	67.53	61.53
93nm nano-chitosan	22.785	76.972	16.58	5.333	6.05	64.45	65
150nm nano-chitosan	11.8368	65.876	22.881	6.866	7.125	54.55	66.55
0.5% Carrageenan	9.87	88.34	20.046	11.33	9.78	65.1	58.34
1% Carrageenan	14.062	93.036	19.8	9.857	9	65.22	64.213
1.5% Carrageenan	22.22	95.897	16.301	8.43	7.2142	68.46	65.745
nano carrageenan 25nm	32.966	97.227	9.45	4.933	5.533	68.83	67.83
nanocarrageenan 34 nm	19.45	83.554	12.64	7.933	5.733	63.53	65.53

IV CONCLUSION

Chitosan and Carrageenan nano particles exhibited non-Newtonian pseudoplastic behavior since the apparent viscosity of edible coating solutions decreased as shear rate increased. The effect of nano particle solutions of chitosan and carrageenan on oil uptake reduction during frying was investigated and compared with that of bulk size of chitosan and carrageenan.

REFERENCES

[1]Pahade, P.K., and Sakhale B. K., Effect of blanching and coating with hydrocolloids on reduction of oil uptake in french fries", International Food Research Journal 19(2):,2012, 697-699.

[2]KangH**.**, KimS., You, Y.,Lacroix, M., HanJ., Inhibitory effect of soy protein coating formulations on walnut (Juglansregia L.) kernels against lipid oxidation. LWT – Food Science and Technology, 51(1),2013, 393–396.

[3]Espitia, P. J. P., Du, W., Avena-Bustillos, R., de, J., Soares, N., de, F. F., et al.,Edible films from pectin: Physical-mechanical and antimicrobial properties – A review. Food Hydrocolloids, 35, 2014,287–296.

[4]GuilbertS.,Gontard, N. &Gorris, L.G.M,Prolongation of the shelf-life of perishable food products using biodegradable films and coatings.Lebensmittel-Wissenschaft Und-Technologie, 29,1996, 10–17.

[5]Falguera, V, Quintero, J. P., Jiménez, A., Mu˜noz, J. A., &Ibarz, A., Edible films and coatings: Structures, active functions and trends in their use. Trends in Food Science and Technology, 22(6), 2011,292–303.

[6] Baldwin, E. A., & Wood, B. ,Use of edible coating to preserve pecans at room temperature,Hort Science, 41(1),2006, 188–192.

[7] Osorio, F. A., Molina, P., Matiacevich, S., Enrione, J., &Skurtys, O ,Characteristics of hydroxy propyl methyl cellulose (HPMC) based edible film developed for blueberry coating,Procedia Food Science, 1, 2011,287–293

[8] Arvanitoyannis, I. S.,Irradiation of food commodities: techniques, applications, detection, legislation, safety and consumer opinion. Academic Press**,**2010.

[9]Barreto, P. L. M., Pires, A. T. N., &Soldi, V. ,Thermal degradation of edible films based on milk proteins and gelatin in inert atmosphere. Polymer Degradation and Stability, 79, 2003, 147–152.

[10] Valero, D., Díaz-Mula, H. M., Zapata, P. J., Guillén, F., Martínez-Romero, D., Castillo, S., et al.,Effects of alginate edible coating on preserving fruit quality in four plum cultivars during postharvest storage, Postharvest Biology and Technology, 77,2013, 1–6.

[11] Steven M. Colo, Alan George and Nick Roye, Coating Rheology OCTOBER WWW.P C I M A G .C O M, 2006**.**

[12] Chen, H., Functional Properties and Applications of Edible Films Made of Milk Proteins, Journal of Dairy Science, 78,1995, 2563-2583**.**

[13]Mate J. I., and Krochta, J. M., Whey Protein Coating Effect on the Oxygen Uptake of Dry Roased Peanuts, Journal of Food Science, 61,1996, 1202-1210.

[14]Brody, A.L., 2005. Packaging. Food Tech., 59: 65-66.

[15]Balasubramania,V.M., Chinnan, M.S., Mallikarjunan, P.and Phillips, R.D., The Effect of Edible Film on Oil UptakeFried Poultry Productand Moisture Retention of A Deep-Fat,Journal of Food Process Engineering 20 (1997) 17-29.

[16]Mellema M., Mechanism and reduction of fat Uptake in Deep Fat Fried Foods, Trends in Food Science and Technology 14(9):2003, 364-373.

[17] Qi, L.; XuZo X., Hu, C., ZU. X., Preparation and antibacterial activity of chitosan nanoparticles, carbohydrateresearch, 339 (16), 2004, pp.2693-2700.

[18]AOAC, 1995. Official methods of analysis, 16th ed. Washington: Association of Official Analytical Chemists.

[19] Hutchison, J., Smith, T.H., and Kulp, K. 1990. Batter and Breading Process equipment. In: Batters and Breadings in Food Processing, K. Kulp, R. Loewe (Eds.), American Association of Cereal Chemists, St. Paul, MN, USA. 163–176.

[20] Steffe, F., Rheology methods in food process Engineering, Second ed, Free man press, Michigan, pp.418, 1996

[21] Abdou, E.S., and Sorour, M.A., "Preparation and characterization of starch/carrageenan edible films", International Food Research Journal 21(1), 2014, pp.191-195.

[22] Abdou, E. S. and Sorour, M.A., Preparation and characterization of starch/carrageenan edible films, International Food Research Journal 21(1), (2014), pp. 191-195.

[23] Li, Q., Dunn, E.T, Grandmaison, E.W. and M.F.A. Goosn, Application and properties of chitosan, Technomic publishing company, Inc. Lancaster, pp.3, 1997.

[24] ReihanehA. Z., Ghavidel, M. G., Ahmad F., MehranA., "Evaluation of Application of Edible Films on Quality Improvement and Reducing -Oil Uptake inPotatoStrips", International Journal of Agriculture and Crop Sciences, Vol., 6(11), (2013), pp. 716-722.

[25]Moyano, P.C., Rioseco V.K. and Gonzalez P.A.,. Kinetics of crust color change during deep-fat fryingof impregnated fresh fries. Journal of Food Engineer, 45, (2002), pp. 149-255.

[26]Albert S, Mittal GS (2002) Comparative evaluation of edible coatings to reduce fat uptake in a deep-fried cereal product. Food Res Int 35: 445-458.

[27]Diaz, A., G. Trystram, O. Vitrac, D. 1999. Dominique and A. Raoult-Wack, Kinetics of moisture loss and fat absorption during frying for different varieties of plantain. J. Food Sci., 79, 291-299.

[28] Salvador, A., Sanz, T. and Fiszman, S.M. 2008. Performance of methyl cellulose in coating batters for fried products. Food Hydrocolloid. 22, 1062-1067. http://www.foodqualitynews.com/Innovation/Addmethyl-cellulose-for-healthy battered-food.