International Food Research Journal 22(3): 1009-1014 (2015)
Journal homepage: *http://www.ifrj.upm.edu.my*

Effect of some hydrocolloids on coating performance of egg base coated fried yam chips

[1*]Alimi, B. A., [2]Shittu, T. A. and [2]Sanni, L. O.

[1]*Department of Food, Agricultural and Bio-Engineering, Kwara State University, Malete, P. M. B. 1530, Ilorin, Kwara State Nigeria*
[2]*Department of Food Science and Technology, Federal University of Agriculture, Alabata, P. M. B. 2240, Abeokuta, Nigeria*

Article history

Received: 8 June 2014
Received in revised form: 20 November 2014
Accepted: 25 November 2014

Keywords

Hydrocolloids
Coating pick up
Frying loss
Model
Egg
Interactive effect

Abstract

The influence of xanthan gum (XG), carboxymethyl cellulose (CMC) and gum tragacanth (GT) mixed with either whole-egg or egg- white at 0.5-1.5% concentrations as coatings in fried yam chips was studied. The parameters studied include coating pick-up (CPU) of the chips prior to frying, cooked yield (CY) and frying loss (FL) of coated fried chips. Egg content (EC), Hydrocolloid type (HT) and concentration (HC) had significant ($p<0.05$) effect on all the parameters studied. Xanthan gum conferred highest CPU and CY, and least FL. Increasing HC significantly increased the CPU, CY and reduced FL for the coated fried samples. Chips coated with egg-white plus hydrocolloid showed higher CPU, CY and lower FL compared with that from whole. CPU was found to be correlated positively with CY (0.986) and negatively with FL (-0.920) ($p \leq 0.01$). Polynomial regression model was the best to predict the effect of CPU on CY ($0.888 \leq r^2 \leq 0.976$) and FL ($0.733 \leq r^2 \leq 0.865$). Highly significant interactive effect of HT and HC ($p \leq 0.001$), and EC ($p \leq 0.01$) underscores the need to conduct further research to determine the optimum combination for reduced frying loss in order to ensure economy of processing.

Introduction

Coating the surfaces of food products prior to deep-fat frying is a popular practice employed to achieve different objectives (Dogan *et al*., 2005; Alimi *et al*., 2013). The quantity of coating that adheres to the food substrate prior to frying, also known as coating pick-up is an important quality factor in coated fried products. Besides limiting the ingress of oil into food core, coating also affects sensory attributes of fried foods (Alimi *et al*., 2014), and in some instances provides additional nutrient to the fried products (Akdeniz *et al*., 2006). Coating pick-up is also important in large scale processing of batter coated products because of its effects on the yield which could determine the final price of the product (Varella and Fiszman, 2011). However, coating of product prior to frying has some technological challenges among which include the loss of coating material during frying or the "blow-off" phenomenon. Blow-off is caused by the rapid evaporation and migration of moisture from the product being fried (Suderman, 1983; corey *et al*., 1987). This results in the loss of coating and product materials, and hastens the degradation of the frying medium as a result of overcooking of the blown off coating particles (Parinyasiri and Chen, 1991). This could affect the appearance quality of the fried products due to darkening imparted by the frying medium. Also, more frying oil would be used with significant production down time recorded because of the need to constantly change the frying oil. Therefore, blow-off obviously has negative influence on the quality of fried products and economy of production.

Hydrocolloids are known to influence the pick-up of a coated product because of their influence on coating viscosity and surface adherence (Nasiri *et al*., 2010).The addition of hydrocolloids to coating formulation was also reported to reduce material loss during frying (Maskat *et al*., 2005). However, it is important to understand the influence of processing variables such as hydrocolloids and egg content on coating pick up prior to frying, cooked yield and frying loss. This will give us information on variables that should be controlled to achieve reduced frying loss and for subsequent optimization of the product properties.

The objectives of this work was to compare the effect of xanthan gum (XG), carboxymethyl cellulose (CMC) and gum tragacanth (GT) as coating adjuncts on the coating performance and quality of yam chips with whole egg or egg-white as coating base. Parameters studied include coating pick-up (CPU)

*Corresponding author.
Email: *bun5574@yahoo.com, buliyaminu.alimi@kwasu.edu.ng*
Tel: + 234 703 671 1250

prior to frying, cooked yield (CY) and frying loss of the coated fried yam chips.

Materials and Methods

Materials

White yam *(Dioscorea rotundata)*, fresh poultry eggs, and refined, bleached and deodorized palm olein oil (Gino Oil, Malaysia) were procured from local market in Ibadan, Nigeria. The food gums used were Xanthan gum (XG) (Fufeng group, Shandong, China), carboxymethyl cellulose (CMC) (Dow Wolf Cellulosic, Bittersfeld, Germany), and gum tragacanth (GT) (Fufeng group, Shandong, China).

Preparation of coating formulation

Fresh poultry eggs were washed with distilled water to remove extraneous materials and cracked to release the contents. Egg white was obtained by careful separation from egg yolk. The coatings were formulated by mixing 0.05-1.5 g XG, CMC, or GT with 1kg whole egg or egg white in a commercial blender (HR2001, Philips, Hong Kong, China) until the mixture was uniform and free of lumps.

Yam chips preparation

White yam tubers were peeled using stainless steel knife and cut into 30 by 45 mm dimension. Chipping was done using vegetable multi-slicer (SF 923-1, CEE Square Ltd., Texas, USA) into 2.5 mm thickness and washed using distilled water to remove surface starch. Yam slices were then blanched in hot water at 75^{o}C in a water bath (NE 122/15136, Clifton, England) for 5 min. Blanched slices were blotted by paper towel to remove loose materials adhering to the surface and excess water prior to coating.

Coating and frying operations

Yam chips (50 g) were dipped into coating formulations, allowed to drain for 30 s to remove excess coating material and deep fried in an electric fryer (S-516, Saisho, Hong Kong, China) at 180^{o}C for 5 min for each set of treatment and controls. Excessive oil was allowed to drain off from the chips after removal from the fryer for about 50 s. The chips were allowed to cool to room temperature before reweighing. Processing parameters determined include the effect of different types and concentration of hydrocolloids on coating pick-up (CPU), cooked yield (CY) and frying loss (FL). They were determined according to the methods published by Hsia *et al*. (1992).

These are briefly: weight of yam chips (Y), weight after coating (C) and weight after frying (F) were taken and processing parameters calculated as follows:

$$CPU(\%) = \frac{C-Y}{Y} * 100 \quad 1$$

$$CY(\%) = \frac{F-Y}{Y} * 100 \quad 2$$

$$FL(\%) = \frac{F-C}{C} * 100 \quad 3$$

CPU was determined after coating but before frying. Three replicates were done for each parameter.

Statistical analysis

All data were analyzed using SPSS version 15.0 software and Microsoft Office Excel 2007. One way analysis of variance (ANOVA) was employed to study the difference between means and where differences existed ($p \leq 0.05$); Duncan Multiple Range Test was used to separate the means. Multiple analysis of variance (MANOVA) using general linear model (GLM) was used to study the effect of independent variables on studied parameters.

Results and Discussion

Coating pick-up

From the results presented in Table 1, CPU was higher with addition of hydrocolloid compared with control samples. The result has shown that addition of hydrocolloid, as low as 0.5%, is capable of increasing CPU to about 26.5 %. This might be due to the viscosity building effects of gums (Xue and Ngadi, 2009). Hydrocolloids have high propensity for water due to the presence of carboxyl groups which attracts hydrogen ions to form hydrogen bonds leading to viscosity build-up within the matrix. Viscosity build up was reported by Hsia *et al*. (1992) to have high positive correlation with CPU. Similar observation was also reported by Maskat *et al*. (2005) for chicken breasts.

The quantity of coating material picked up before frying could be critical to the overall quality of the fried product for certain reasons. It may determine the amount of barrier provided against the influx of frying oil into the product crust. Type of hydrocolloid had significant ($p<0.05$) influence on CPU (Table 1). Xanthan gum gave significantly higher CPU than any other hydrocolloid in this study. This might be due to greater stability conferred by its structural properties. XG molecule contains side chains that bind its helical structure thus making the molecule a stiff rod (Whistler and Bemiller, 1997; Higiro *et al*., 2006). Since gum addition to the coating formulation resulted in higher CPU values due to the viscosity building effects of gums (Akdeniz *et al*., 2006), the

Table 1. Effect of processing variables on some parameters of coated fried yam chips

EC	HT	HC	CPU*	CY	FL
EW	XG	0.5	36.68±3.94^{ef}	-0.44±5.06^{fg}	27.19±1.62^{f}
		1.0	45.46±3.22^{gh}	16.04±1.70^{jk}	20.21±1.33^{d}
		1.5	55.50±2.05^{k}	36.29±1.61^{n}	12.35±0.51^{a}
	CMC	0.5	26.65±4.49^{c}	-21.38±3.78^{c}	37.95±0.86^{i}
		1.0	34.91±3.92^{def}	-2.92±3.68^{f}	28.05±0.87^{f}
		1.5	44.30±1.15^{gh}	21.46±2.10^{kl}	15.83±0.94^{bc}
	GT	0.5	32.66±3.19^{cde}	-11.98±3.24^{de}	33.66±0.94^{h}
		1.0	40.51±5.79^{fg}	7.69±6.08^{hi}	23.39±1.63^{e}
		1.5	52.24±3.30^{jk}	31.92±3.18^{mn}	13.35±0.26^{a}
	0	0	16.4±2.48^{ab}	-40.87±2.93^{a}	49.31±1.97^{k}
WE	XG	0.5	31.63±1.49^{cde}	-6.29±1.80^{ef}	28.81±0.61^{f}
		1.0	41.25±8.45^{fg}	10.4±10.27^{ij}	21.96±2.70^{e}
		1.5	51.24±4.05^{ijk}	31.11±2.68^{mn}	13.3±0.63^{a}
	CMC	0.5	20.29±4.75^{b}	-28.49±2.48^{b}	40.53±0.67^{j}
		1.0	28.72±2.31^{cd}	-11.32±3.02^{de}	31.12±1.11^{g}
		1.5	41.20±5.98^{fg}	16.44±6.14^{jk}	17.56±0.98^{c}
	GT	0.5	29.11±2.30^{cd}	-12.54±2.36^{d}	32.27±0.68^{g}
		1.0	35.62±5.25^{ef}	3.58±2.72^{gh}	23.59±1.41^{e}
		1.5	48.85±2.38^{hij}	26.08±4.24^{lm}	15.32±1.51^{b}
	0	0	12.69±1.07^{a}	-44.05±1.09^{a}	50.34±0.74^{k}

Data are presented as mean ±standard deviation. Mean values with different superscripts in the same column are significantly different at $P < 0.05$

(EC: egg content; HT: hydrocolloid type; HC: hydrocolloid concentration; EW: egg white; WE: whole egg; XG: xanthan gum; CMC: carboxymethyl cellulose; GT: gum tragacanth; CPU: coating pick-up; CY: cooked yield; FL: frying loss)

*Adapted from Alimi *et al*. (2013)

highest CPU observed with addition of XG could also be due to higher viscosity imparting capacity in the coating formulation. Furthermore, its ability to be completely soluble in both hot and cold water with high solution viscosity even at low concentration (Xue and Ngadi, 2009) could also enhance its high CPU capability. These characteristics of XG might be responsible for its synergistic interaction with some culinary ingredients (Sworn, 2009) including egg as shown in this study.

Coating pick-up was increasing significantly ($p<0.05$) with hydrocolloid concentration (Table 1). Hydrocolloids are generally hydrophilic in nature with presence of free carboxyl groups (Alloncle and Doublier, 1991). Increased hydrocolloid concentration led to higher number of free carboxyl groups which implied more sites for hydrogen bonding with subsequent increase in viscosity and improved adhesion capability. Therefore, increased hydrocolloid concentration enhanced CPU. Generally, egg-white coated chips had higher CPU compare to those of whole egg (Table 1). This might be due to higher moisture content of egg-white. Higher moisture content in egg-white could have resulted in more hydrogen bonding and thus increasing the viscosity of the mixture.

Cooked yield

Cooked yield (CY) is expressed as the weight change relative to the raw yam chips. Weight change may largely be due to factors such as coating loss, moisture migration and mass loss due to separation of parts from the samples (Maskat *et al*., 2005). The CY for coated chips containing hydrocolloid was significantly ($p<0.05$) higher than the controls (Table 1). Structural re-orientation due to the formation of higher numbers of cross-linked structures that prevent movement of water and mass out of the coated food matrix (Xue and Ngadi, 2010) could be responsible for the higher CY. Ability of hydrocolloids to form films could also be a factor (Akdeniz *et al*., 2006). HUSE and co-workers (1998) had posited that coating is essential to limit mass transfer during frying.

Significant effect of hydrocolloid type on CY of coated fried yam chips is evident in Table 2. XG had the greatest CY ($p<0.05$). This could be due to its structural and other properties enumerated above. Also, chips coated with egg-white plus hydrocolloids had higher CY value compared with that for whole egg. The increase in CY with increased hydrocolloid concentration could be due to improved barrier against mass transfer out of the chips. Similar observation had earlier been made by Maskat *et al*. (2005).

Relationship between CPU and CY

There was significant ($p \leq 0.01$) linear correlation between CPU and CY with Pearson correlation value of 0.986. The effects of CPU on CY for the treatments were subjected to four regression models namely, linear, logarithmic, polynomial and exponential.

Table 2. Significance of the main and interactive effects of processing variables on the studied parameters

Variables	CPU	CY	FL
EF	***	***	***
HT	***	***	***
HC	***	***	***
EF.HT	0.869	0.391	**
EF.HC	0.784	0.818	0.530
HT.HC	0.936	0.212	***
EF.HT.HC	0.974	0.754	0.097

EF: egg form; HT: hydrocolloid type; HC: hydrocolloid concentration; CPU: coating pick up; CY: cooked yield; FL: frying loss; **: p≤0.01, ***: p≤0.001

All the models gave good fit to the data (p≤0.01). However, polynomial was the best model that can be used to predict the effect of CPU on CY for all the treatment combinations; since it has the highest coefficient of determination (R^2) value for each of the treatments. The final forms of the equations and their respective coefficients of determination (R^2) are presented below:

Egg-white

XG $y = 0.003x^2 + 1.518x - 57.41$ $R^2 = 0.952$ (4)

CMC $y = 0.043x^2 - 0.993x - 17.30$ $R^2 = 0.888$ (5)

GT $y = -0.010x^2 + 2.868x - 88.36$ $R^2 = 0.937$ (6)

Whole egg

XG $y = 0.016x^2 + 0.556x - 37.94$ $R^2 = 0.976$ (7)

CMC $y = 0.025x^2 + 0.422x - 41.36$ $R^2 = 0.945$ (8)

GT $y = -0.032x^2 + 4.314x - 105.5$ $R^2 = 0.942$ (9)

Where,

$y = CY$

$x = CPU$

The polynomial relationships between CPU (x) and CY (y) of coated fried yam chips is presented in Figure 1.

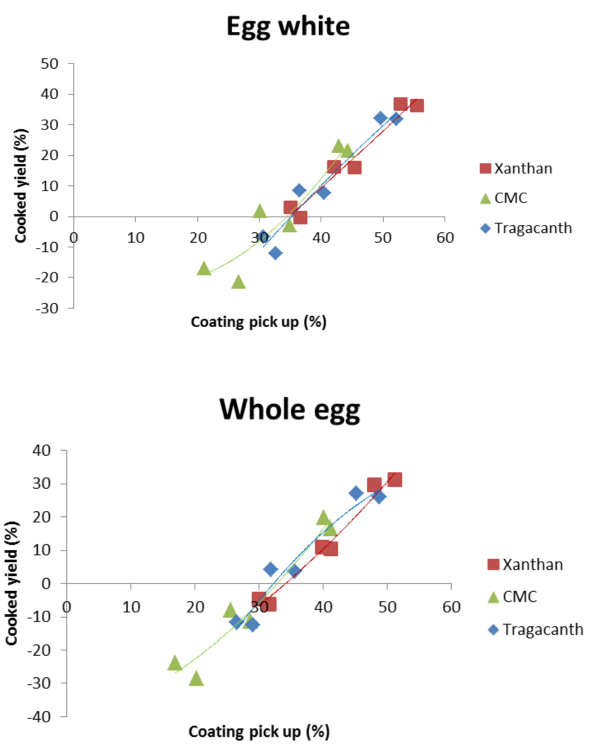

Figure 1. Model of effect of coating pick up on cooked yield

Frying loss

Frying loss was most pronounced in samples without hydrocolloids (Table 1). Significant differences in FL between the hydrocolloids could be attributed to their adhesion properties and differences in barrier provided by the hydrocolloids against mass movement (Table 1). Therefore, XG provided the most effective barrier to mass loss while the least was CMC. The reduction in FL with increased hydrocolloids concentration as shown in Table 3 showed the importance of gums in preventing blow-off phenomenon. Generally, whole egg coated chips had higher FL compared with egg white coated chips. Combination of the type of hydrocolloid and application of egg, that is form of egg, as well as type of hydrocolloid and hydrocolloid concentration had significant impact on the frying loss of the coated chips with p≤ 0.01 and 0.001, respectively (Table 2).

Relationship between CPU and FL

There was negative significant correlation (p≤0.01) between CPU and FL with Pearson correlation value of -0.920. This implied that FL was significantly decreasing with increased CPU. Therefore, those factors that enhanced CPU led to the reduction of FL. Also, the best regression model that accurately described the effect of CPU on FL was polynomial. The final forms of the equations and their respective coefficients of determination (R^2) are presented below.

Egg white

XG $$y = 0.001x^2 - 0.883x + 54.33 \quad R^2 = 0.860 \tag{10}$$

CMC $$y = -0.027x^2 + 0.967x + 24.80 \quad R^2 = 0.733 \tag{11}$$

GT $$y = 0.012x^2 - 1.945x + 78.57 \quad R^2 = 0.837 \tag{12}$$

Whole egg

XG $$y = -0.008x^2 + 0.053x + 33.29 \quad R^2 = 0.857 \tag{13}$$

CMC $$y = -0.014x^2 - 0.073x + 42.80 \quad R^2 = 0.865 \tag{14}$$

GT $$y = 0.027x^2 - 2.890x + 88.74 \quad R^2 = 0.839 \tag{15}$$

Where

$$FL = y$$

$$CPU = x$$

The polynomial relationships between CPU (x) and FL (y) of coated fried yam chips is presented in Figure 2.

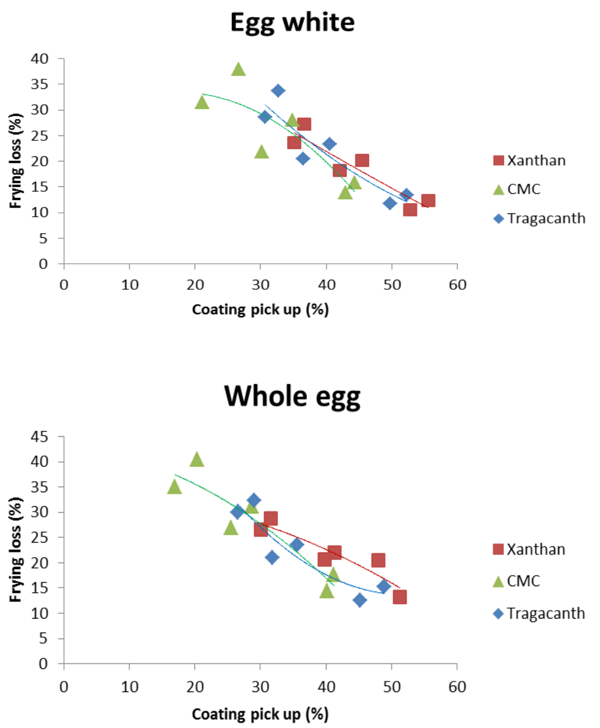

Figure 2. Model of effect of coating pick up on frying loss

Conclusions

This study has shown that generally, combination of egg-white with hydrocolloids conferred higher CPU and CY and reduced FL compared with whole egg. Increasing addition of hydrocolloids led to increased CPU, CY and reduced FL. The results also indicated that XG gave the best performance as it resulted in highest CPU, CY and lowest FL. Furthermore, multiple polynomial regressions equations that could be used to predict CY (0.888 ≤r^2≤0.976) and FL (0.733≤r^2≤0.865) from CPU values were generated. Highly significant interactive effect of hydrocolloid type and concentration (p≤0.001) as well as hydrocolloid type and egg form (p≤0.01) on frying loss underscores the need to conduct further research to determine the optimum hydrocolloid-egg content combination for reduced frying loss in order to ensure quality products and economy of processing.

References

Akdeniz, N., Sahin, S. and Sumnu, G. 2006. Functionality of batters containing different gums for deep –fat frying of carrot slices. Journal of Food Engineering 75: 522-526.

Alimi, B. A., Shittu, T. A., Sanni, L. O. and Arowolo, T. A. 2013. Effect of some hydrocolloids as adjuncts on the quality of whole egg or egg white coated fried yam chips. Journal of Food, Agriculture and Environment

11(1): 132-138.

Alimi, B. A., Shittu, T. A. and Sanni, L. O. 2014. Effect of Hydrocolloids and Egg Content on Sensory Quality of Coated Fried Yam Chips. Journal of Culinary Science and Technology 12: 168-180.

Alloncle, M. and Doublier, J. L. 1991. Viscoelastic properties of maize starch/hydrocolloid pastes and gels. Food Hydrocolloids 5(5): 455–467.

Corey, M. L., Gerdes, D. L. and Grodner, R. M. 1987. Influence of frozen storage and phosphate pre-dips on coating adhesion in breaded fish portions. Journal of Food Science 52: 297–299.

Dogan, S. F, Sahin, S. and Sumnu, G. 2005. Effects of batters containing different protein types on the quality of deep-fat fried chicken nuggets. European Food Research Technology 220: 502-508.

Higiro, J., Herald, T. J., Alavi, S..and Bean, S. 2007. Rheological study of xanthan and locust bean gum interaction in dilute solution: effect of salt. Food Research International 40: 435-447.

Hsia, H. Y., Smith, D. M. and Steffe, J. F. 1992. Rheological properties and adhesion characteristics of flour-based batters for chicken nuggets as affected by three hydrocolloids. Journal of Food Science 571: 16–24.

Huse, H. L., Mallikajurnan, P., Chinnan, M. S., Hung, Y. C. and Phillips, R. D. 1998. Edible coatings for reducing oil uptake in production of akara (deep-fat frying of cowpea paste). Journal of Food Processing and Preservation 22: 155–165.

Maskat, M. Y., Yip, H. H. and Haryani,, M. M. 2005. The performance of a methyl cellulose treated coating during the frying of a poultry product. International Journal of Food Science and Technology 40: 811-816.

Nasiri, F. D., Mohebbi, M., Yazdi, F. T. and Khodaparast, M. H. H. 2010. Effects of Soy and Corn Flour Addition on Batter Rheology and Quality of Deep Fat-Fried Shrimp Nuggets. Food Bioprocess Technology 5(4): 1238-1245.

Parinyasiri, T. and Chen, T. C. 1991. Yields and breading dispersion of chicken nuggets during deep-fat frying as affected by protein content of breading flour. Journal of Food Processing Preservation 15: 367–374.

Suderman, D. R., Wiker, J. and Cunningham, F. E. 1981 Factors affecting adhesion of coating to poultry skin: effects of various protein and gum sources in the coating composition. Journal of Food Science 46: 1010–1011.

Suderman, D. R. 1983. Use of batters and breadings on food products: A review. In: Suderman, D.R. and Cunningham, F. (Eds), Batter and breading, p. 2-7. Westport, Connecticut: Avi Publishing Company.

Sworn, G. 2009. Xanthan gum. In: Phillips, G. O. and Williams, P. A., (Eds) Handbook of hydrocolloids, p 186-203. Cambridge: Woodhead Publishing Ltd.

Varella, P. and Fiszman, M. 2011. Hydrocolloids in fried foods: a review. Food Hydrocolloids 25: 1801-1812.

Whistler, R. L. and Bemiller, J. N. 1997. Carbohydrate chemistry for food scientists. St. Paul, MN: Eagan Press..

Xue, J. and Ngadi, M. (2010): Effects of methyl cellulose, xanthan gum and carboxymethyl cellulose on thermal properties of batter system formulated with different flour combinations. Food Hydrocolloids 23: 286-295.