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Effect of Pre-Drying and Hydrocolloid Type on Colour and Textural Properties of Coated Fried Yam Chips

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ABSTRACT

The effect of pre-drying and coating on colour and texture of yam chips were investigated. The colour parameters studied were lightness index (L^*), hue angle (h) and browning index (BI). Peak force (PF) of penetration was observed for texture. Coating pick-up (amount of coating adhering to the samples) prior to frying was determined and moisture content of fried samples was also determined. The type of hydrocolloids used in the coating formulation had significant ($p < 0.05$) effect on coating pick-up, initial moisture content and texture of the chips; while samples that were not pre-dried had higher pick-ups and moisture contents. Pre-dried samples were darker brown in colour and harder in texture than samples that were not pre-dried as evidenced by their higher browning index and peak force values, respectively, thus enhancing the colour and texture of the chips.

Keywords: Hydrocolloids, pre-fry drying, frying, colour, texture.

Introduction

Fried yam chip is a popular street vended delicacy in Sub-Saharan Africa countries. It is a typical convenience or fast food product that meets the time saving requirement for the fast growing and industrialized society where many people eat outdoor. Thus, it is consumed as a snack in these societies. A variant of fried yam chips popularly consumed in Nigeria is coated with whipped whole egg. However, for some health reasons some consumers avoid frequent consumption of products containing egg yolk since yolk contains significant amount of cholesterol (Coimbra *et al.*, 2006). Therefore, efforts to replace whole egg with egg white as the coating material in such products may be of practical interest.

Coating the surfaces of products prior to deep-fat frying is a popular practice that helps to control moisture loss and oil uptake during frying. It also helps to modify textural and colour properties of fried products. In some instances, coating provides additional nutrient to the fried products (Dogan *et al.*, 2005; Akdeniz *et al.*, 2006). However, coating of product prior to frying has some technological challenges among which is 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). Loss of coating results in the loss of product material and hastens the degradation of the frying medium as a result of overcooking of the blown off coating particles (Parinyasiri and Chen, 1991). Addition of hydrocolloids to the coating reduces coating loss during frying (Maskat *et al.*, 2005), but enhances water retention which could result in reduced crispiness of fried foods (Primo-Martin *et al.*, 2010).

Peak force, also known as fracturability, is one of the parameters used in the objective measurement

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of solid food texture. It is the corresponding force at the highest curvature point in a force-distance diagram (Miranda and Aguilera, 2006). Texture determination is an important quality check in fried chips especially where hydrocolloids are used in the preparation of coating for fried product (Varella and Fiszman, 2011).

Effect of partial drying of food particles before frying has been a subject of many studies. Krokida *et al.* (2001) reported reduction in the rate of moisture loss and oil uptake during frying of potato strips due to pre-fry drying and suggested that appropriate drying time should be determined to control quality of French fries. Debnath *et al.* (2003) reported that pre-fry drying of a flour-based snack, using convective air drying, resulted in final fried product with less oil uptake and acceptable sensory attributes. Pedreschi and Moyano (2005) also reported decrease in oil absorption and significant increase in crispness of fried potato slices as a result of pre-frying drying. However, information on the effect of pre-fry drying on hydrocolloid-batter coated fried products is scarce.

The objective of this study was to study the effect of pre-drying treatment on colour and texture of coated fried yam chips.

Materials and Methods

Materials

White yam (*Dioscorea rotundata*) procured from local market in Ibadan and fresh poultry eggs obtained from a poultry farm were used for this study. Refined, bleached and deodorized palm olein oil (Gino Oil, Malaysia) was obtained from a food market in Ibadan. Xanthan gum (XG) (Quest International, Brazil), carboxymethyl cellulose (CMC) (Walocel CRT 30.000 PA, Dow Wolf Cellulosic GMBH) and gum tragacanth (GT) (Fufeng group, China) were supplied by Mekang Resources and Allied Distribution Lagos.

Methods

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 (Aminlari *et al.*, 2005). The coatings were formulated by mixing 0.05 g XG, CMC, or GT with 1kg egg white in a commercial blender (HR2001, Philips, China) at a proportion of 0.05 g/kg 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 mm by 45 mm dimension. Chipping was done using vegetable multi-slicer (SF 923-1, CEE Square Ltd., Houston, Texas, USA) into 2.5 mm thickness and washed using distilled water to remove surface starch. Yam slices were then blanched in water at 75°C in a water bath (NE 122/15136, Clifton, England) for 5 min (Sobukola *et al.*, 2008). Blanched slices were blotted by paper towel to remove loose materials adhering to the surface and excess water prior to drying or coating (Pedreschi and Moyano, 2005).

Pre-drying operation

Blotted blanched yam slices were spread in single layer on a tray with spaces between slices for air movement and dried in convective hot air oven (SG 94/04/609, Gallenkamp, United Kingdom) at 75°C for 15 min (Fan *et al.*, 2006).

Coating and frying of chips

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°C for 5 min (Aminlari *et al.*, 2005) 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 following analyses were carried out on fresh and pre-dried samples:

Coating pick-up

Amount of coating adhering to the substrate was considered as coating pick-up (CPU) and calculated as:

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

Where Y is the weight of yam chips and C is the weight of yam chips after coating.

Moisture content determination

Moisture of samples was determined by weight loss after drying 5 g samples in a forced air oven at 105°C for 24 h (AOAC, 1990).

Colour determination

Colour of coated fried yam chips was determined using the method described by Shittu *et al* (2009). The histogram of lightness/darkness (L), greenness/redness (a) and blueness/yellowness (b) colour channels of the software (Corel Photo-paint 12) used ranges from -127 to +128 (i.e. L value for Black = 0 to -127 and White = 0 to +127; b value for green = 0 to -127 and red = 0 to +128; b value for blue = 0 to -127 and yellow = 0 to +128). The following equations were used to convert these values to the usual 0 to 100 scale for L* and -100 to +100 scale for a* and b* channels:

$$L = 100 * \bar{L}/128 \quad \text{since } \bar{L} \text{ is } 0 \text{ (lightness)} \qquad (2)$$

$$a = 100 * \bar{A}/128 \quad \text{since } \bar{A} \text{ is } 0 \text{ (redness)} \qquad (3)$$

$$b = 100 * \bar{B}/128 \quad \text{since } \bar{B} \text{ is } 0 \text{ (yellowness)} \qquad (4)$$

$\bar{L}$, $\bar{A}$ and $\bar{B}$ are the mean values of lightness (L), redness (a) and yellowness (b) colour channels (respectively) generated from corel PHOTO-PAINT 12 environment (Shittu *et al.*, 2009).

The hue (H) and browning index (BI) were calculated as follows:

$$H = \tan^{-1} b/a \qquad (5)$$

$$BI = (100\,(x - 0.31))/0.172 \qquad (6)$$

Where

$$x = (a + 1.75L)/(5.645L + a - 3.012b) \qquad (7)$$

Chip's fracturability

Fracturability of fried chips was determined as peak puncture force using the universal testing machine (M500-25kN, Testometric AX, Rochdale, England). The scheme of deformation, i.e. deformation force (F) against distance curve was generated and displayed on the monitor connected to the equipment.

Statistical Analysis

All experiments were done in triplicate. Data were analysed using SPSS version 15.0 software. One way analysis of variance (ANOVA) was employed to study the difference between means and where differences existed ($p < 0.05$), Duncan Multiple Range Test was used to separate the means. Multivariate analysis of variance was used to study the main and interactive effect of independent variables on the studied quality attributes

Result and Discussion

Hydrocolloid type and pre-fry drying had significant effect ($p < 0.05$) on coating pick-up (Table 1). As shown in Figure 1, xanthan gum had the highest coating pick-up for both treatments. The presence of hydrocolloids in the coating formulation enhance coating pick-up because of their ability to impart viscosity (Hsia *et al.*, 1992). Generally, coated chips that were not pre-dried had higher coating pick-ups (16.68-36.38%) than the pre-dried samples (15.71-35.08%). This could be due to wetter surface of the former. This was apparent because generally wet surfaces are needed for solid particles to adhere. Moreover, the binding effect of hydrocolloid is enhanced at higher water activity (Patil *et al.*, 2001).

Table 1: P-value showing the main and interactive effect of independent variables on quality of egg-white coated fried yam chips

Variables	CPU	MC	L*	Hue	BI	PF
HT	***	***	0.768	0.146	0.164	*
Predrying	***	***	***	**	***	***
HT*predrying	0.833	0.652	*	0.876	0.306	0.791

CPU: coating pick up; MC: moisture content; L*: lightness index; BI: browning index; PF: peak force; HT: hydrocolloid type; ***: $p < 0.001$; **: $p < 0.01$; *: $p < 0.05$

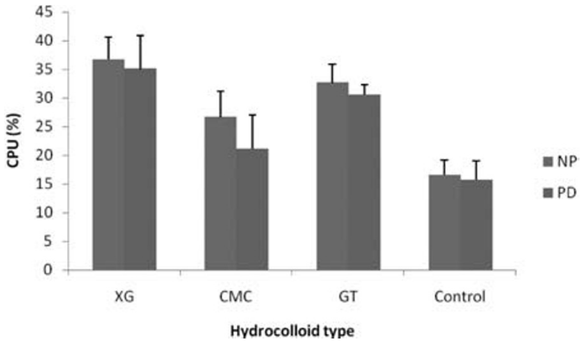

Fig. 1: Effect of pre-fry drying on coating pick-up of hydrocolloid-egg white coated fried yam chips (NP: chips not pre-dried; PD: pre-dried chips; XG: xanthan gum; CMC: carboxymethyl cellulose; GT: gum tragacanth)

As shown in Figure 2, significantly ($p < 0.05$) lower final moisture contents were observed for pre-dried samples (3.73 – 18.13%) compared to samples that were not pre-dried (4.14 – 19.24%) regardless of hydrocolloid type. The pre-drying treatment could have reduced the superficial moisture on the chips, thereby, leading to lower moisture content. However, the type of hydrocolloid had significant effect ($p < 0.05$) on the moisture content of fried chips. Chips with xanthan gum in coating formulation had significantly ($p < 0.05$) highest moisture content. The presence of more hydroxyl group in xanthan gum molecules could have increased the sites for hydrogen bonding resulting in more affinity for binding water (Aguirre-Cruz *et al.*, 2005).

A major factor that determines colour changes in fried food is browning reaction which is often affected by processing temperature, food or ingredient composition, water activity and so on. Hydrocolloid type (HT) did not have significant ($p<0.05$) effect on lightness index of egg white coated fried yam chips (Table 1). However, pre-drying and interaction of hydrocolloid type and pre-drying significantly influenced the lightness index of the coated chips ($p < 0.05$). The pre-drying of yam slices led to paler coated fried chips as evidenced by the lower L* values (Table 2). This could be attributed to Maillard's browning reaction (Ibarz *et al.*, 1999). Akdeniz et al. (2006) explained that the ability of gums to bind moisture prevents dehydration and inhibits maillard browning reaction. Pre-drying would normally reduce water activity of the yam chips and this could have enhanced non enzymatic browning.

Hue angle is the angle in theta that a line joining the point in the hunter space with the origin makes with the horizontal axis and its value equal to 0, 90 and 180 would be red, yellow and green, respectively (Francis, 1998). A hue value shift from 0 to 90 shows colour change from red to yellow whilst a shift from 90 to 180 shows a colour change from yellow to green. Values in between these represent blends of colours.

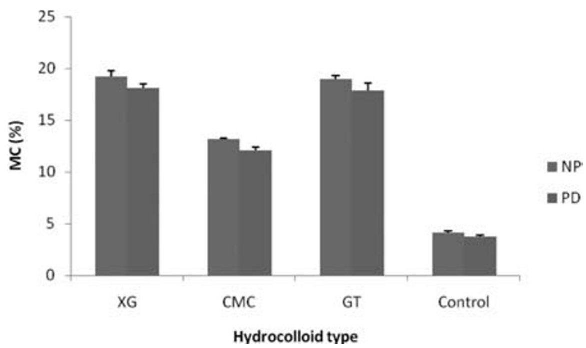

Fig. 2: Effect of pre-fry drying on MC of hydrocolloid-egg white coated fried yam chips (MC: moisture content; NP: chips not pre-dried; PD: pre-dried chips; XG: xanthan gum; CMC: carboxymethyl cellulose; GT: gum tragacanth)

Hue angle (h) values, of all the chips were above 70^o, showing a very clear transition from red to yellow. This indicates the development of golden brown colour (Maskan, 2001) which is highly preferred by fried chips consumers. Pre-dried samples had significantly ($p < 0.05$) higher h values compared with samples that were not pre-dried (Table 2). This could also be due to reduction in moisture interference with browning reactions.

Browning index, BI, which represents the purity of brown colour has been reported as an important parameter in processes where enzymatic and non-enzymatic browning takes place (Maskan, 2001). As can be observed in Table 2, pre-dried samples had significantly ($p < 0.05$) higher browning index values than the corresponding samples that were not pre-dried. This could be as a result of lower moisture content of pre-dried samples.

Table 2: Colour and textural properties of coated fried yam chips

	Hydrocolloid	L*	Hue angle (O)	BI	PF (N)
NP	XG	63.30 ± 2.14[a]	75.53 ± 2.01[a]	94.91 ± 5.50[bc]	5.10 ± 1.84[a]
	CMC	61.67 ± 9.10[a]	75.50 ± 2.02[a]	97.26 ± 28.83[bc]	7.45 ± 1.63[ab]
	GT	62.30 ± 1.54[a]	75.60 ± 0.98[a]	93.58 ± 1.45[bc]	6.80 ± 2.12[ab]
	Control 1	65.78 ± 6.90[a]	81.73 ± 1.50[b]	51.03 ± 13.80[a]	18.30 ± 4.67[c]
PD	XG	57.30 ± 1.08[a]	76.68 ± 1.43[a]	111.92 ± 1.53[c]	13.30 ± 3.54[abc]
	CMC	62.13 ± 11.02[a]	77.14 ± 2.53[a]	109.26 ± 60.34[c]	15.20 ± 5.52[bc]
	GT	59.94 ± 1.25[a]	77.04 ± 0.48[a]	100.04 ± 8.91[c]	11.00 ± 4.38[abc]
	Control 2	61.82 ± 10.85[a]	85.26 ± 1.11[c]	58.56 ± 18.67[ab]	19.45 ± 0.21[c]
Mean square	Between groups	24.10	50.93	2027.35	58.12
	Within group	47.62	2.66	607.64	11.81
Variance (F)		0.506	19.152	3.336	4.921
Significance (P)		0.82	0.000	0.013	0.02

NP: chips not pre-dried; PD: pre-dried chips; XG: xanthan gum; CMC: carboxymethyl cellulose; GT: gum tragacanth; L*: lightness index; BI: browning index; PF: peak force

Peak force (PF), also known as fracturability, is a measure of hardness of the chips. Hydrocolloid type and pre-drying had significant effect ($p < 0.05$) on the fracturability (PF) of hydrocolloid-egg white coated chips. The significantly ($p < 0.05$) higher values of peak force for pre-fried compared with samples that were not pre-dried could be due to hardening of the chips as a result of lower moisture content (Table 2). This is similar to the observation of Pedreschi and Moyano (2005) while working on the effect of pre-drying on texture of potato chips.

Conclusion

Pre-drying of yam slices prior to coating reduced the coating pick-up and final moisture content of coated fried yam chips. Furthermore, pre-drying led to significant ($p<0.05$) improvement of colour by lowering L* values and significantly increasing hue angle, browning index and peak force values. Conclusively, as suitability of pre-treatments depend on the attributes of interest in final products, pre-drying can be used as a pre-treatment step in hydrocolloid-batter coated fried products because of its obvious beneficial effect on the studied quality of hydrocolloid-egg white coated fried yam chips.

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