Effect of hydrocolloids and Egg Content on Sensory Quality of Coated Fried Yam Chips

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Abstract

This study investigated the role of hydrocolloid and egg content as coating ingredients on the sensory quality of fried yam chips (FYC). The independent variables studied include hydrocolloid type (xanthan gum, gum tragacanth and carboxymethyl cellulose (CMC)), hydrocolloid concentration (0.5-1.5%) and egg content (egg white or whole egg). The coated chips were evaluated for appearance, texture, taste, flavour and overall acceptability using nine-point hedonic scale. Descriptive sensory evaluation of the samples using generic method was also conducted. FYC without coating were used as the control samples. Hydrocolloid type, concentration and egg content had significant ($p<0.05$) effects mainly on the appearance and texture of the FYC. Only the hydrocolloid concentration significantly influenced the overall acceptability of the samples. Samples containing CMC plus egg-white were more acceptable in terms of appearance and texture. Generally, the acceptability scores decreased significantly with increased hydrocolloid concentration ($p<0.05$). Also, coated fried chips were rated better than the control. Appearance had highest significant correlation ($p<0.01$, $r=0.764$) with overall acceptability. Out of over 50 descriptors generated by the trained panelists, eight of them were agreed upon as non-redundant, discriminatory attributes of the coated fried yam chips. Similarity map of the descriptors were defined by two principal components (1 and 2) accounting for 53.06 % and 40.18 %, respectively, of total variance of rotation sums of squared loadings. Puffiness had significant negative correlation with overall acceptability ($p<0.05$, $r=-0.986$). This study shows that careful selection and formulation of coating ingredients could help to improve on consumer acceptability of coated fried yam chips. Information generated could be used in further optimization of the processing variables for the production of consumer acceptable coated fried yam chips.

"**Keywords"**: Hydrocolloid; egg content; sensory quality; descriptors, fried yam chips

INTRODUCTION

Frying, the immersion of a food product in edible oil or fat heated above the boiling point of water is globally used to prepare food with taste and texture widely appreciated by the consumers (Hubbard and Farkas, 1999). Fried foods have continued to be popular despite the concern over the fat content in human diet. Frying leads to high heat transfer rate responsible for physical, chemical and sensory modification of the final fried products. These modifications generally affect the overall quality of fried products (Moreira *et al*., 1999). Quality of raw materials (foods, frying oil), frying temperature, frying duration, processing method, food geometry, fryer and food pretreatments such as coating also affect the quality of final fried products (Aminlari et al., 2005)

Coating the surfaces of products in deep-fat frying can be regarded as a value added process because of its effects on quality of fried products such as control of moisture loss and oil uptake during frying, as well as provision of nutrient, a crisp texture and the development of desired colour (Dogan *et al*., 2005). It was described by Garmakhamy *et al*., (2008) as an alternative solution to comply with both health concern and consumer preference. However, coating of product prior to frying has some technological challenges. Among them is the loss of coating material during frying, also known as the "blow-off" phenomenon which is caused by the rapid evaporation and migration of moisture from the product being fried (Suderman, 1983; Corey *et al.*, 1987). Loss of coating, according to Parinyasiri and Chen (1991), led to loss of product material and hastens the degradation of the frying medium as a result of overcooking of the blown off coating particles. However, application of hydrocolloids as an adjunct in the coating has been reported to reduce coating loss during frying (Alimi *et al*., 2013; Maskat *et al*., 2004).

Hydrocolloids in fried foods are known to cause reduced oil uptake. Their presence in coating materials also assists in enhancing batter viscosity, improving coating adhesion and pick-up properties, better mechanical resistance of the outer crust and freeze-thaw stability (Akdeniz *et al*. 2006; Varella and Fiszman 2011). However, it is important to know the sensory perception of the resulting foods (Varella and Fiszman, 2011).

Fried yam chip is a popular street vended delicacy in sub-Sahara African 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 these societies 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.

The characteristics of the added ingredients -hydrocolloids, whole egg or egg white- and their interactions could produce noticeable differences in the physical and sensory pattern of this product which could influence consumer perception. Insight into the contributions of these ingredients and their intrinsic interactions on the attributes that are important for the sensory

liking of the products and weighted influence of the attributes on the overall liking or acceptance of the chips could be of great importance for the purpose of understanding the liking pattern and subsequent optimization of the product properties (Menichelli *et al*., 2013). This insight will give us information about the main players in the sensory liking of the products and how these players interact.

The objectives of this study was to investigate the role of hydrocolloids and egg content as coating ingredients on sensory acceptability and descriptive sensory profile of fried yam chips and evaluate the relationship within and between these ingredients and sensory parameters.

MATERIALS AND METHODS

MATERIALS

White yam (*Dioscorea rotundata*) procured from local market in Ibadan, Nigeria and fresh poultry eggs obtained from a poultry farm were used for the study. Refined, bleached and deodorized palm olein oil (Gino Oil, Malaysia) was obtained from a Food market in Ibadan, Nigeria. 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 Limited Lagos, Nigeria.

PREPARATION OF COATING FORMULATION

Fresh poultry eggs were washed with distilled water to remove extraneous materials. Egg white was obtained by careful separation from egg yolk. The coatings were formulated by mixing 0.05 to 0.15g XG, CMC, or GT with 1kg whole egg or egg white using commercial blender (HR2001, Philips, 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 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^{o}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 coating (Pedreschi and Moyano, 2005).

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^{o}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.

SENSORY ACCEPTABILITY

A Fifty man sensory evaluation panel from the students and staff of College of Food Science and Human Ecology, University of Agriculture, Abeokuta, Nigeria assessed the coated fried yam chips based on the selected quality attributes (appearance, texture, taste, flavor and overall acceptability) using a nine point hedonic scale where 9 represented like extremely, 5 was neither like nor dislike and 1 dislike extremely. Panel member aged between 18 – 40 years were selected based on interest and availability. Evaluation was done inside the sensory laboratory of the department of Food Science and Technology of the institution under white light. The sensory testing facility consisted of 10 individual testing booths with controlled lighting and positive airflow. Samples were given a random 3-digit code and serving order was randomized and balanced across panelists (Meilgaard *et al*., 1999). The panelists were presented with 1 sample at a time identified by random 3-digit code (Meilgaard *et al*., 1999). Water and unsalted crackers were also served to panelists to clean their palates between each sample tasting.

DESCRIPTIVE SENSORY PROFILE

Panelists for descriptive analysis were selected from members of affective panel based on their continued interest and sensory acuity. Questionnaire was administered to assess the participants personality based on their motivation, ability to follow instruction, their health stand, dietary habit, verbal creativity and concentration among others as recommended in ISO 8586-1:1993 and ASTM STP 913, 1986

Following the screening procedure, 14 members were selected to participate in generic descriptive analysis. The training and assessment of the samples were for the period of four weeks with 3 sessions per week. The first two sessions were used to introduce the members to the concept of descriptive analysis. During the latter sessions, the panel members were given free hands to generate terms, reference points and scaling procedure with guidance from the team leader. The discriminatory attributes and scaling procedure were agreed upon by consensus. Just about right (JAR) rating scale numbering from 1 – 5 was agreed upon for quantitative analysis.

Samples for descriptive analysis were selected from samples used for hedonic ranking based on degree of liking (overall acceptability). Four most acceptable samples were presented for sensory evaluation. The evaluation was done in cubicles under white light. Each sample was presented in duplicate.

Statistical analysis was done using SPSS version 15.0. Statistically significant differences ($p<0.05$) in the sensory scores were determined by one way analysis of variance (ANOVA) and mean comparison were done by Duncan Multiple Range Test. Multiple analysis of variance using general linear model (GLM) was used to study the effect of independent variables on sensory quality of coated fried yam chips. Pearson's correlations and principal component analysis were used to evaluate the relationship between the studied sensory attributes.

RESULTS AND DISCUSSION

Generally, mean scores of the coated chips for all the sensory attributes, except texture at 1.5% hydrocolloid concentration, were above 5 as shown in Table 1. This is an indication that the coated chips were acceptable to the panelists. Irrespective of egg content, acceptability scores of

appearance and texture of the chips were decreasing with increased hydrocolloid concentration. In our previous work (Alimi *et al*., 2013), increased hydrocolloid concentration led to increase in moisture content (implying increased water activity, a_w) of the chips which inhibited Maillard browning and increased sogginess of the chips. This could have been responsible for the reduced textural and appearance acceptability of the chips observed in this study. Except for textural attributes, panelists' acceptability pattern of other sensory attributes was similar with that of the control sample. Presence of yolk in whole egg which makes the samples creamier could be responsible for the panelists' preference for appearance, taste and flavour of whole egg coated chips. There was insignificant difference in panelists' preference for flavour for all the treatments. This could be due to the fact that all the samples were coated with same egg base treatment. Saha *et al*. (2009) had reported that flavour is not expected to be different in samples with the same base treatment.

Table 1. **Sensory scores of coated fried yam chips**

Egg content (EC)	Hydrocolloid type (HT)	Hydrocolloid concentration (HC) (%)	Appearance	Texture	Taste	Flavour	Overall acceptability
EW	XG	0.5	6.85±1.40^{de}	6.46±1.47^{gh}	5.96±2.08^{abc}	6.21±1.57^{ab}	6.19±1.62^{a-e}
	XG	1.0	6.75±1.47^{b-e}	5.27±1.69^{cde}	6.21±1.52^{bcd}	6.23±1.74^{ab}	6.08±1.69^{a-e}
	XG	1.5	6.52±1.69^{bcd}	4.31±1.75^{a}	5.90±1.97^{abc}	6.10±1.40^{ab}	5.79±1.79^{a-d}
WE	XG	0.5	6.60±1.43^{bcd}	5.98±1.59^{fg}	6.33±1.37^{bcd}	6.27±1.14^{ab}	6.52±1.37^{def}
	XG	1.0	6.25±1.68^{bcd}	5.08±1.40^{bcd}	6.21±1.34^{bcd}	6.29±1.24^{ab}	6.06±1.39^{a-e}
	XG	1.5	5.60±2.11^{a}	4.27±1.51^{a}	5.58±1.74^{ab}	6.10±1.46^{ab}	5.50±1.58^{a}
EW	CMC	0.5	7.33±1.29^{e}	7.44±1.09^{jk}	5.71±2.18^{ab}	6.44±1.49^{b}	6.46±1.82^{c-f}
	CMC	1.0	6.94±1.19^{de}	5.98±1.67^{fg}	6.63±1.68^{cd}	6.54±1.66^{b}	6.67±1.72^{ef}
	CMC	1.5	6.83±1.45^{cde}	4.79±1.82^{abc}	6.67±1.58^{cd}	6.60±1.71^{b}	6.35±1.68^{b-f}
WE	CMC	0.5	6.46±1.61^{bcd}	6.77±1.46^{hi}	6.00±1.73^{abc}	6.40±1.36^{b}	6.42±1.444^{c-f}
	CMC	1.0	6.46±1.60^{bcd}	5.58±1.38^{def}	6.19±1.67^{bcd}	6.38±1.28^{b}	5.92±1.57^{a-d}
	CMC	1.5	6.56±1.21^{bcd}	4.15±1.40^{a}	6.19±1.63^{bcd}	6.33±1.21^{b}	5.77±1.42^{abc}
EW	GT	0.5	6.65±1.23^{bcd}	6.90±1.06^{hij}	6.04±1.15^{abc}	6.46±1.22^{b}	6.21±1.13^{a-e}
	GT	1.0	6.85±1.17^{de}	5.79±1.25^{efg}	6.35±1.60^{bcd}	6.33±1.48^{b}	6.06±1.49^{a-e}
	GT	1.5	6.54±1.43^{bcd}	4.63±1.51^{abc}	6.13±1.65^{bcd}	6.33±1.29^{b}	5.67±1.67^{ab}
WE	GT	0.5	6.52±1.29^{bcd}	5.88±1.78^{efg}	6.65±1.45^{cd}	6.19±1.27^{ab}	6.19±1.36^{a-e}
	GT	1.0	6.44±1.29^{bcd}	5.15±1.53^{bcd}	6.38±1.36^{bcd}	6.29±1.25^{ab}	6.10±1.19^{a-e}
	GT	1.5	6.04±1.60^{ab}	4.54±1.50^{ab}	6.52±1.37^{cd}	6.06±1.42^{ab}	5.94±1.48^{a-e}
EW	-	-	6.96±1.03^{de}	7.17±1.10^{ijk}	5.98±1.83^{abc}	6.31±1.03^{ab}	6.50±1.15^{c-f}
WE	-	-	7.35±1.49^{e}	6.44±1.58^{gh}	6.88±1.04^{d}	6.65±1.23^{b}	7.00±1.17^{f}
Control	-	-	6.13±1.62^{abc}	7.63±1.08^{k}	5.29±2.06^{a}	5.65±1.48^{a}	5.58±1.69^{a}

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)

Means of sensory preference scores of coated fried yam chips as affected by hydrocolloid type are presented in Table 2. The chips with CMC in coating were the most preferred in terms of appearance, texture and flavour. This higher preference of CMC coated samples could be related to its coating pick up (CPU) ability which was reported to be the lowest of the three hydrocolloids (Alimi et al., 2013). The appearance of fried product is affected by the extent of browning reactions since this affects products colour. Moreover, the extent of browning also depends on coating composition especially the moisture content (or a_w), protein and sugar contents (Dogan et al., 2006). Hydrocolloids in coating formulation are generally known to enhance coating pick up (Hsia et al., 1992). Increase in CPU was linked with increase moisture content of the chips which could reduce the extent of Maillard reaction (Akdeniz et al., 2006) and cause sogginess in the chips (Miranda and Aguilera, 2006). The reduced peak force of the same product could have caused its higher sensory texture preference.

Table 2: Effects of hydrocolloid type on the sensory scores of coated fried yam chips

HT	Appearance	Texture	Flavour	Taste	Overall acceptability
XG	6.43^{a}	5.23^{a}	6.20^{a}	6.03^{a}	6.02^{a}
CMC	6.76^{b}	5.78^{c}	6.45^{b}	6.23^{ab}	6.26^{a}
GT	6.51^{a}	5.48^{b}	6.28^{ab}	6.34^{b}	6.03^{a}

Mean values with different superscripts in the same column are significantly different at $P < 0.05$

(n=300)

Hydrocolloid concentration had significant ($p<0.05$) effect on appearance, texture and overall acceptability of coated fried yam chips (Table 3). Rankings of these attributes were decreasing with increased hydrocolloid concentration. This observation shows that panelists preferred coated chips with minimal hydrocolloid treatment.

Table 3: Effect of hydrocolloid concentration on the sensory scores of coated fried yam chips

HC (%)	Appearance	Texture	Flavour	Taste	Overall acceptability
0.5	6.74^{b}	6.57^{c}	6.33^{a}	6.11^{a}	6.33^{b}
1.0	6.61^{b}	5.48^{b}	6.34^{a}	6.33^{a}	6.15^{b}
1.5	6.35^{a}	4.45^{a}	6.26^{a}	6.16^{a}	5.84^{a}

(n=300)

($p < 0.05$)

Table 4 shows the effect of egg content on coated chips. Panelists' overall preference for egg-white coated chips shows the practicality of producing egg white coated fried yam chips especially for health conscious people.

Interaction of hydrocolloid concentration and hydrocolloid type had significant ($p<0.05$) effect on taste (Table 5).

Table 4: Effects of egg content on the sensory scores of coated fried yam chips

EC	Appearance	Texture	Flavour	Taste	Overall acceptability
EW	6.81^{b}	5.73^{b}	6.36^{a}	6.18^{a}	6.16^{a}
WE	6.33^{a}	5.27^{a}	6.26^{a}	6.23^{a}	6.05^{a}

(n=450)

Table 5: P value of main and interactive effect of independent variables on sensory attribute of coated chips

Processing variables	Appearance	Texture	Flavour	Taste	Overall acceptability
HT	0.017	0.000	0.101	0.068	0.100
HC	0.006	0.000	0.737	0.266	0.001
EC	0.000	0.000	0.278	0.647	0.258
HT*HC	0.383	0.072	0.961	0.048	0.835
HT*EC	0.636	0.294	0.556	0.130	0.066
HC*EC	0.832	0.169	0.844	0.061	0.364
HT*HC*EC	0.277	0.615	0.980	0.834	0.514

HT

Correlation matrix of sensory attributes of coated chips is presented in Table 6. Appearance, flavour and texture had the most significant ($p<0.001$) effect on overall acceptability of coated fried yam chips. The significant correlation ($p<0.001$) observed for visual appearance with flavour and overall acceptability agreed with the submission of Mendoza *et al*. (2007) that consumers associate the appearance of chips with flavour in determining their acceptance or rejection of products.

Table 6: Correlations Matrix of sensory attributes of coated fried yam chips

	Appearance	Texture	Taste	Flavour	Overall acceptability
Appearance	1				
Texture	0.458*	1			
Taste	0.371	-0.273	1		
Flavour	0.658**	0.013	0.624*	1	
Overall acceptability	0.764**	0.486*	0.564**	0.698**	1

**.Correlation is significant at the 0.01 level (2 tailed)

*. Correlation is significant at the 0.05 level (2 tailed)

Web diagram of descriptive sensory profile of four most acceptable samples is shown in Fig. 1. Surface shiny, golden brown, brightness, grainy, oiliness, hardness, puffiness and crispness were agreed upon by panel members as discriminative, non-redundant attributes of coated fried yam chips from over fifty attributes generated.

Correlation matrix of descriptive attributes with overall acceptability is shown in Table 7. Surface shiny had positive significant ($p \leq 0.05$) correlations with oiliness and negative correlations ($p \leq 0.05$) with grainy and crispness. Golden brown and grainy had negative correlations ($p \leq 0.05$). Also, oiliness had negative correlation with hardness ($p \leq 0.05$) and crispness ($p \leq 0.01$). Significant negative correlation ($p \leq 0.05$) was observed between puffiness and overall acceptability. Puffiness (swelling) of the chips has been reported to be dependent on hydrocolloid concentration and protein content (Mellema, 2003). In an earlier work (Alimi et al., 2013), swelling of the coated fried yam chips was reported to be increasing with increased hydrocolloid concentration and also enhanced oil uptake by increasing the depth of capillary and creating a lipophilic surface for oil to enter.

Principal component analysis (PCA) score plot of descriptive sensory attributes of coated fried yam chips is shown in Figure 2. Similarity map of the attributes were defined by two principal components (1 and 2) accounting for 53.06 % and 40.18 %, respectively, of total variance of rotation sums of squared loadings. Panelists' acceptance of the coated chips was influenced by such descriptors as brightness, hardness, crispness and grainy, since they are close to each other on the score plot. While surface shiny, golden brown, oiliness and puffiness had negative relationship with overall acceptability. Increase in hydrocolloid concentration was reported above to enhance puffiness (swelling) and oiliness of the chips. Hence, there is a need for further study to determine the optimal hydrocolloid concentration to produce consumer acceptable coated fried yam chips. Surface shiny had highest negative value for component 1 while crispness had highest positive value. For component 2, overall acceptability had highest positive value while puffiness had highest negative value.

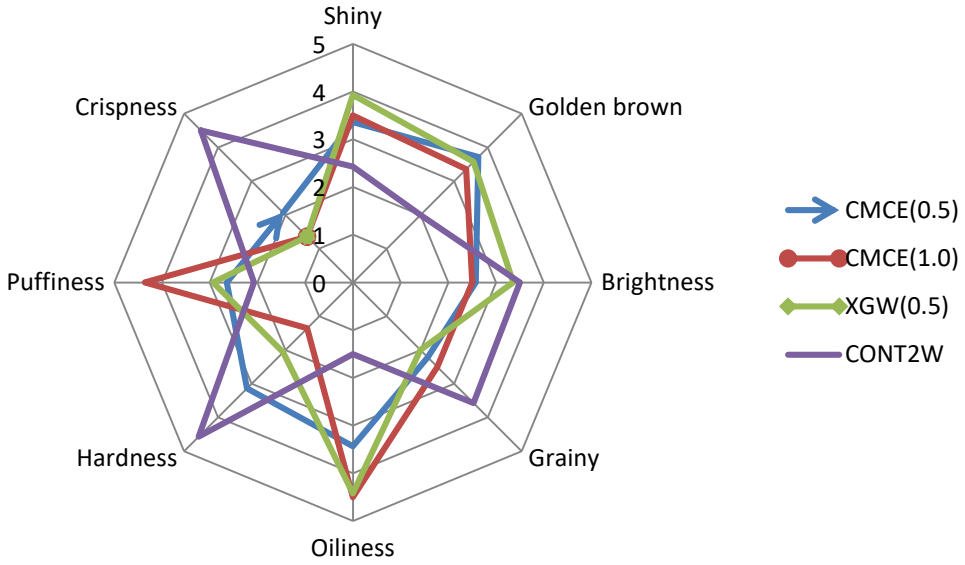

Figure 1: Web diagram showing the sensory profile of most preferred samples

CMCE (0.5): CMC treated (0.5%) egg-white coated chips; CMCE(1.0): CMC treated (1.0%) egg-white coated chips; XGW(0.5): XG treated (0.5%) whole egg coated; CONT2W: without hydrocolloid, whole egg coated pre-fry dried chips

Table 7: Correlations Matrix of Descriptive Sensory Data

	Surface Shiny	Golden brown	Brightness	Grainy	Oilness	Hardness	Puffiness	Crispness	Overall acceptability
SurfaceShiny	1								
Goldenbrown	.898	1							
Brightness	-.341	-.626	1						
Grainy	-.957(*)	-.975(*)	.446	1					
Oilness	.951(*)	.866	-.526	-.881	1				
Hardness	-.857	-.742	.550	.742	-.970(*)	1			
Puffiness	.551	.485	-.668	-.421	.779	-.900	1		
Crispness	-.959(*)	-.924	.575	.926	-.991(**)	.938	-.729	1	
Overall acceptability	-.521	-.533	.781	.437	-.759	.870	-.986(*)	.727	1

* Correlation is significant at the 0.05 level (2-tailed).

** Correlation is significant at the 0.01 level (2-tailed).

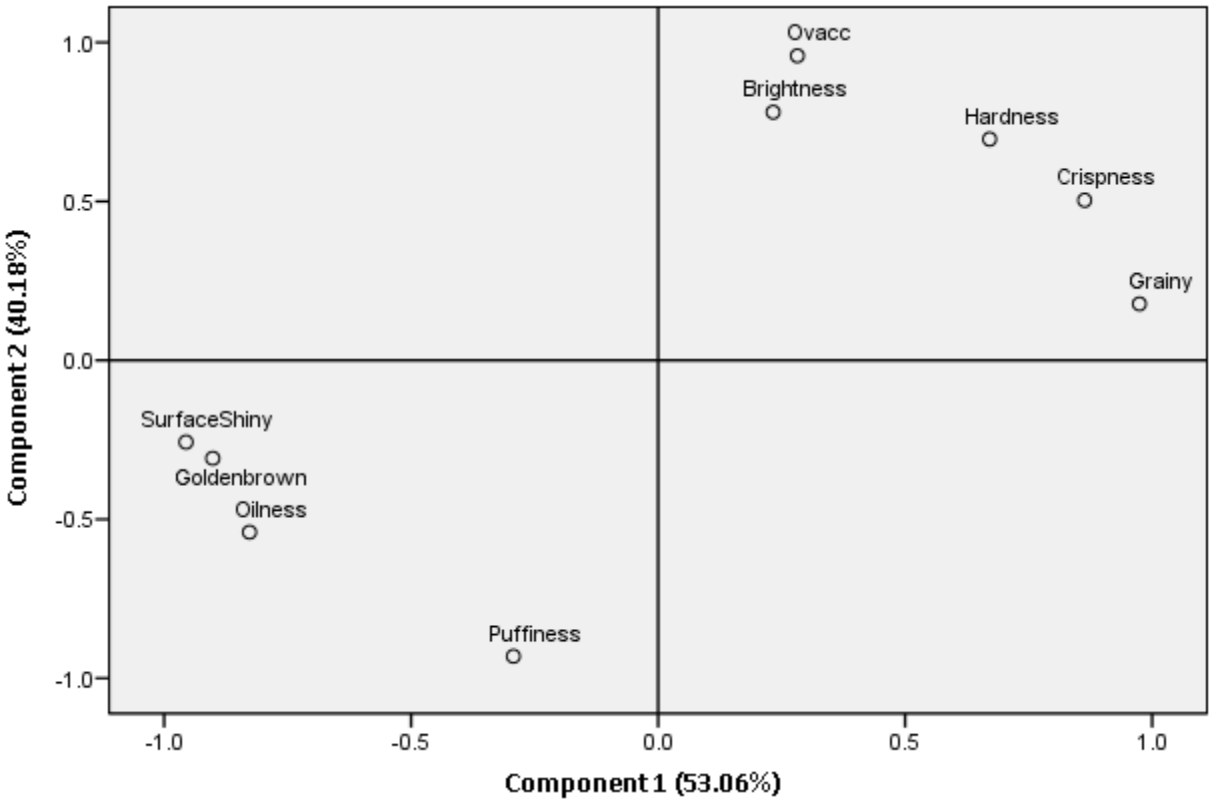

Figure 2: Scores plot of the descriptive sensory data for coated fried yam chips

CONCLUSION

This study investigated the role of independent variables in the consumer liking and sensory profile of coated fried yam chips. Consumer acceptability of egg white and whole egg coated fried yam chips varied with egg white coated chips being preferred to whole egg ones. Overall acceptability of the chips was influenced by hydrocolloid concentration. This study established the relationship between the visual appearance, flavour, puffiness and overall acceptability of coated chips and showed that careful selection and formulation of coating ingredients could help to improve on sensory quality and consumer acceptability of coated fried yam chips. Chips with minimal hydrocolloid treatment were preferred by the panelists. Information generated could be used in further optimization of the processing variables for the production of consumer acceptable coated fried yam chips.

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