MEAT LIPID PROFILE AND FLAVOUR ATTRIBUTES OF DEEP-FRIED CHICKEN BREAST BREADED WITH ALTERNATIVE COATING

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ABSTRACT

The meat lipid profile and flavour attributes of deep-fried breaded chicken breasts were evaluated with alternative edible coatings. Four types of coatings (wheat flour, sweet potato flour, cassava flour, and cocoyam flour) were utilized for the study. The coatings were designated T_1, T_2, T_3, and T_4 respectively. The deep-fried chicken meats were analyzed for meat lipid profile, oxidative stability, and flavour attributes. All data collected were subjected to a one-way analysis of variance. Results showed that the application of the edible alternative coatings significantly influenced ($p<0.05$) the chicken meat lipid profile. High-density lipoprotein increased, with breaded chicken meat in the T_4 group recording the highest value. Cholesterol and low-density lipoprotein were reduced in favour of T_4. Alternative edible coatings improved the oxidative stability of the meat. Using cocoyam flour as a coating material for deep-frying resulted in lower TBARS values ($p<0.05$). The scores for sensory attributes were not significantly different ($p>0.05$) in flavour and overall acceptability. However, the colour, tenderness, and juiciness of the edible coated samples were significantly different, with T_4 receiving higher tenderness and juiciness scores than the controls. It was concluded that the alternative coatings, especially cocoyam, could be a viable alternative to wheat in reducing bad cholesterol and improving chicken meat's oxidative stability and flavour attributes.

Keywords: Breading, Cocoyam flour, Lipoproteins, Oxidative stability, Sensory evaluation

INTRODUCTION

There is an increasing global demand for deep-fat fried foods due to their highly desirable and unique sensory properties, accessibility, and availability. Yet, a primary concern consumers and relevant stakeholders raised with its frequent consumption is its high-fat content (Liberty *et al*., 2019). According to Nahab *et al*. (2016), elevated amounts of dietary fat in fried products increase the risk of non-communicable diseases, including obesity, coronary heart disease, and type 2 diabetes. Health complications of frequent consumption of fried foods have led to recent responses in awareness of reducing fat uptake during deep-fat frying (Adrah *et al*., 2022).

From the standpoint of meat, chicken is one of the main components of the daily diets of many families in developed countries. Every home appreciates chicken meat because it is free of religious restrictions and taboos (De Liu *et al.,* 2012). Chicken is rich in protein, vitamins, and minerals and contains a reduced level of cholesterol and calories when compared to red meat from cattle, goats, etc. (Biesalski, 2005; Jaturasitha *et al*., 2008; Choe *et al.,* 2010). Although it has a high acceptance rate, chicken meat has challenges as it concerns consumers' health.

Cooking through frying results in foods acquiring an appealing golden-brown colour, with an enhanced physical appearance of the product. Additionally, this method generates enticing aromas that elevate consumer acceptance of the foods (Ishak *et al.,* 2016). The high caloric content of fried foods, contributed by their high-fat content, has been considered a significant contributor to the increased weight gain in consumers (Ananey-Obiri *et al.,* 2018; 2020). About 10 - 40 % of the total food product weight is attributed to a high amount of oil uptake by the food matrix during frying (Sayon-Orea *et al.,* 2013). Not only is fried food rich in calories and fat, it is associated with cardiovascular-related diseases, high blood pressure, diabetes, obesity, cancer, etc., which eventually could lead to death (Sun *et al.,* 2019). In light of these heightened health challenges, food scientists worldwide are searching for eco-friendly and sustainable measures to reduce the fat absorbed by food products during deep-frying. One such measure currently explored is the application of natural preservatives in the food industry. Using natural preservatives has informed researchers to develop edible coatings (Adrah *et al*., 2022). The use of flour as a coating for food, therefore, becomes a viable option.

In the Nigerian food industry, only wheat flour is used as a commercial coating for deep-fried meat and other foods. However, wheat flour has limitations in terms of cost and competition for making confectionaries (Lima *et al*., 2024). Nigeria is reportedly one of the major consumers and importers of wheat from many countries, including Ukraine (Balana *et al*., 2022; Donley, 2022). With the demand for wheat significantly met from imports, the price recently has fluctuated dramatically due to the ongoing conflict in Ukraine, making it less affordable for many households (Balana *et al*., 2022).

Addressing these current challenges has called for exploring alternative coatings from other sources that are affordable and available in economic quantities. In most Sub-Saharan countries, such potential alternatives include cassava, sweet potato, and cocoyam flours. Nigeria remains the world's largest producer of cassava and also leads in the production of sweet potatoes in Africa, with an estimated annual production of 3.3 metric tonnes (NRCRI, 2023). Nigeria and Ghana are the leading countries producing cocoyam (Oke and Bolarinwa, 2012).

Smallholder farm families cultivate these alternative coating sources as a guarantee against food insecurity. At harvest, the tubers can be processed into various products for home and industrial use. In Nigeria, cocoyam can be converted into flour, which can be further utilized in baking and making "*Usung ikpong*," the pounded form of boiled cocoyam. The flour can also be used as a soup thickener and for making porridge for people with gastrointestinal disorders (Adeyanju *et al*., 2019). Studies by Onwulata and Konstance (2002) suggested that when mixed with whey protein, cocoyam flour could serve as weaning food for babies. Likewise, the flour made from cassava can be utilized in making "*fufu*" and confectionaries such as puff-puff, spaghetti, macaroni, chin-chin, pies of all sorts, bread, and cassava beer in the brewing industry (Ene, 1992; Olomu, 1995; Charles *et al.,* 2007). The flour from sweet potato can also be prepared into a stiff paste to make "*Amala*," a delicacy in South Western Nigeria (Scott *et al*., 2000). Despite their availability, affordability, and utilization, the perishable nature of these crops makes them highly susceptible to spoilage, hence the need to process them into various products.

However, to the best of our knowledge, there is scarce information from studies on how these alternatives, as an edible coating, impact the meat lipid profile and flavour attributes of the deep-fried chicken breast. It was hypothesized that cocoyam flour as a coating for food would negatively impact the lipid profile and flavour attributes of chicken breasts. Therefore, this study seeks to investigate the impact of these alternative coating materials on the meat lipid profile and flavour attributes of deep-fried chicken breast.

MATERIALS AND METHODS

Study Location: The study was conducted in October 2023 at the Department of Animal Science Laboratory, Faculty of Agriculture, Akwa Ibom State University, Obio Akpa Campus. The Laboratory is between latitude 4°97'N and 4°57'N and longitude 7°76'E and 7°45'E (GPS, 2023).

Meat Preparation: A total of 24 male broiler chickens of 8 weeks of age were purchased from the Commercial Farm of the Department of Animal Science, Akwa Ibom State University. The birds were slaughtered and allowed to bleed for two minutes to allow the proper outward flow of blood before being scalded, de-feathered, and cleaned. Evisceration was carried out, the breast muscle was removed from the carcass, and the visible bone of the meat was trimmed. Using a clean and sharp kitchen knife, the carcass was cut into chunks 14 cm long and 5 cm wide in the same direction as the muscle fibre. The chunk was further cut into sizeable portions (7 x 5 cm^2) in length and width, and their weights were homogenized before frying. This was done with little modification according to the method described by Jiya *et al*. (2014). The breast cuts of the weighed chicken were randomly allotted into four treatments with three replicates each.

Acquisition and Preparation of Breading Materials: Fresh and mature sweet potato, cassava, and cocoyam tubers free from damage, bruising, and decay were purchased from the local market in Abak Local Government Area, Akwa Ibom State. They were washed in clean water to remove dirt and debris, after which the peels were removed using a sharp knife. The peeled tubers and roots were further sliced into thin portions using a manual kitchen food processor and oven-dried for two days before grinding into fine powder. The ground powder was further sieved to obtain a smooth, uniform texture and then packaged in air-tight containers before use (Calverley, 1998). Wheat grains were sun-dried and ground into powder. The containers with each flour were labelled as WF (wheat flour), SPF (sweet potato flour), CF (cassava flour), and CYF (cocoyam flour).

Standardized Marinade Mixture: The marinade formula for the chicken breast muscle consisted of water (1000 ml), salt, ginger, garlic, pepper, nutmeg, and mixed spices, about 5% (each) of the weight of the chicken breast muscle. The fabricated meat cuts were kept in the marinade mixture for 12 hours under refrigerated temperature (4^oC) as recommended by USDA (2023).

Meat Breading: The dry flour from each treatment was mixed with water to create various batters. The egg white was used as a binder to make the batter firm. Cuts of the marinated chicken meat were dipped into the batter slurry and afterwards drained for 10 seconds. The immersion process was repeated until the liquid drainage was absent. The meat cuts were then rolled in the flour for each treatment until a uniform coating was attained.

Deep Frying Procedure: Vegetable oil acquired from a grocery store was pre-heated to a temperature of 180 – 200°C in a deep-frying pan using cooking gas as a heat source. The coated chicken breast strips were dipped into the oil and turned at an interval of two minutes in the frying oil as described by Gokalp *et al*. (1999). The temperature of the oil was regulated using a thermometer.

Meat Lipid Profile and Oxidative Stability: A portion of a 100 g sample of meat was collected from each treatment to evaluate their lipid profiles. Parameters assayed include total cholesterol, high-density lipoprotein, triglycerides, and low-density lipoprotein. These were conducted using the methods described by Wybenga *et al.* (1970), Bucolo and David (1973), and Seigler and Wu (1981).

Meat samples for oxidative stability analysis were stored at refrigerated temperatures for nine days. Measurements were taken on days 0, 3, 6, and 9. Each meat sample (5 g) from the breast muscle of each replicate was homogenized in 15 ml of distilled water. Sample homogenate (5 ml) was transferred into a test tube. The oxidative stability was determined as the 2-thiobarbituric acid reactive substance (TBARS) value according to the method described by Ahn and Maurer (1990). Lipid oxidation was reported as milligrams of malondialdehyde (MDA) per kilogram of meat.

Flavour Analysis: Twelve trained panellists, comprising students and staff members of the Faculty of Agriculture, Akwa Ibom State University, were recruited for the evaluation test. A nine-point hedonic scale of 1 = extremely dislike to 9 = extremely like, as described by Ekpo *et al*. (2022), was used. The parameters assessed include colour, tenderness, Juiciness, flavour, ease of fragmentation, residue after chewing, apparent adhesion, and overall acceptability. After eating each sample, each scorer was presented with saltless biscuits and bottled water to neutralize flavour carryover.

Experimental Design: The study was laid in a completely randomized design with four treatments, the alternative coatings for the breading of chicken meat. A total of 24 male broiler chickens were used for the study and were randomly assigned to the treatments which consisted of 3 replicates each. The treatments were labelled thus: Treatment 1: Wheat flour, Treatment 2: Sweet potato flour; Treatment 3: Cassava flour; and Treatment 4: Cocoyam flour.

Statistical Analysis: Data from the study was subjected to the one-way analysis of variance using the SPSS package. The significant difference between means was compared using Duncan's Multiple Range Test (Duncan, 1955).

RESULTS AND DISCUSSION

Table 1: Meat lipid profile of deep-fried chicken breast breaded with alternative coatings

Parameters	T_1 (WF)	T_2 (SPF)
Total cholesterol	85.67 ± 2.25^{b}	83.67 ± 1.26^{ab}
HDL-Cholesterol	50.17 ± 2.08^{ab}	50.50 ± 2.00^{ab}
LDL-Cholesterol	23.17 ± 0.58^{ab}	23.50 ± 1.00^{b}
Triglyceride	77.33 ± 2.25	76.67 ± 2.93
	T_3 (CF)	**T_4 (CYF)**
Total cholesterol	85.33 ± 1.04^{b}	81.50 ± 1.00^{a}
HDL-Cholesterol	47.50 ± 3.46^{a}	53.17 ± 2.52^{b}
LDL-Cholesterol	24.83 ± 0.58^{c}	20.67 ± 0.76^{a}
Triglyceride	77.50 ± 1.73	76.33 ± 1.04

abc: Means with different letter superscripts on the same row are significantly different ($p<0.05$), WF = Wheat flour, SPF = Sweet potato flour, CF = Cassava flour, CYF = Cocoyam flour, HDL = High-density lipoprotein, LDL = Low-density lipoprotein

The result of the meat lipid profile of deep-fried chicken breaded with alternative coatings indicated that the alternative coatings significantly influenced ($p<0.05$) the total cholesterol (TC), high-density lipoprotein (HDL), and low-density lipoprotein (LDL) levels of the meat across the treatments (Table 1). However, triglyceride levels were not significantly affected ($p>0.05$). Meat breaded with CYF (T_4) recorded the lowest cholesterol value, while those breaded with WF (T_1) and CF (T_3) recorded the highest value ($p<0.05$). This may be attributed to the antioxidant properties of cocoyam, which significantly reduced the cholesterol of the meat. This result was in agreement with the findings of Dilworth *et al.* (2012) and Gayathri (2014) who reported high antioxidant properties in cocoyam. Studies by Naczk and Shahidi (2006) highlighted those foods derived from plants, including root and tubers, to consist of a wide range of non-nutrient phytochemicals that are synthesized as secondary metabolites. The compounds include saponins, phenolic compounds, glycoalkaloids, phytic acids, carotenoids, and ascorbic acid. Each performs different bioactivity, such as antioxidant, immunomodulatory, antimicrobial, antidiabetic, antiobesity, and hypocholesterolemic (Chandrasekara and Kumar (2016).

Low-density lipoprotein (bad cholesterol) was also highest in T_3, while T_4 recorded the lowest value. High-density lipoprotein (good cholesterol), however, recorded the highest significant value for chicken breast breaded with CYF (T_4), while those with CF (T_3) recorded the lowest value. The disparity observed in lipoprotein values in this study indicates that the rich antioxidant and bioactive compounds in the coating materials might be hypocholesterolemic, able to reduce bad cholesterol and increase good cholesterol in the meat as they are made ready to be consumed (Son *et al.*, 2007; Chandrasekara and Kumar, 2016). It is worthy of note that HDL is boosted by the presence of unsaturated and polyunsaturated fats, including linolenic and linoleic acids, which are high in the coatings used. The result of this study corroborates the findings of Yousef *et al*. (2004), Talukder and Sharma (2010), and Ekpo *et al*. (2022).

The TBARS values of deep-fried chicken breast breaded in alternative coatings are shown in Figure 1. The initial TBARS values of coated samples were 0.30 ± 0.02, 0.28 ± 0.01, 0.27 ± 0.02, and 0.27 ± 0.02 mg MDA/kg for T_1, T_2, T_3, and T_4, respectively.

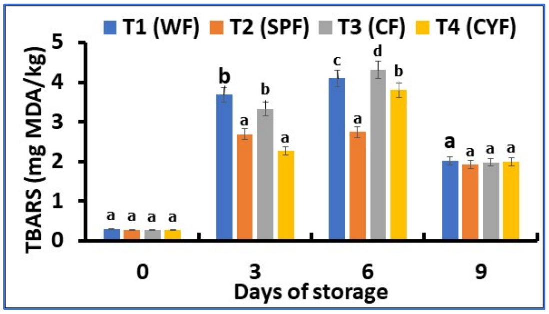

Figure 1: Duration effect of alternative coating on TBARS (mg MDA/Kg) of deep-fried chicken breast

These values increased significantly till day 6, when they recorded a peak of 4.10 ± 0.10, 2.75 ± 0.13, 4.33 ± 0.03, and 3.88 ± 0.13 mg MDA/kg for T_1, T_2, T_3, and T_4, respectively ($p<0.05$). TBARS values declined to 2.02 ± 0.10, 1.93 ± 0.06, 1.98 ± 0.08, and 2.00 ± 0.05 mg MDA/kg on day 9 for T_1, T_2, T_3, and T_4, respectively. The spontaneous reaction of food lipids with oxygen through a series of chain reactions of free radicals is considered lipid oxidation (Shahidi and Hossain, 2022). It occurs in three phases: initiation, propagation, and termination. The formation of lipid-free radicals in the presence of catalysts (heat, metals, light or oxygen, and reactive nitrogen species) is obtained at the initiation phase. The formation of peroxyl radicals results from the reaction of these radicals with oxygen. Peroxyl radicals react with other lipid molecules at the propagation phase to form hydroperoxides and new free radicals. This phase is characterized by a high consumption of oxygen and an increase in peroxide and hydroperoxide content (Ayala *et al*., 2014). Finally, at the termination phase, all free radicals that have been accumulated begin to interact with each other, forming non-radical products. This phase has reduced oxygen consumption and decreased hydroperoxide contents (Gavahian *et al*., 2018). As noticed, TBARS values markedly observed a bell-shaped curve of production of MDA and other markers of oxidation, followed by degradation. This effect was noted among fried samples in all alternatively coated groups and the control. Danowska-Oziewicz and Karpi’nska-Tymoszczyk (2005) reported that the concentration of TBARS follows a bell-shaped curve in lipids exposed to high temperatures. This observation can be credited to the relatively higher coating yield recorded for these treatments and the higher antioxidant properties of cocoyam, which subjected the coated samples to higher antioxidant agents than other treatment samples. Also, starch-based coatings are usually preferred to other coating alternatives regarding oxygen barrier properties (Kramer, 2009). These coatings create a barrier between atmospheric oxygen and the chicken breast samples, decreasing the oxidation rate. Therefore, applying an edible coating such as the ones used in this study (WF, SPF, CF, and CYF) could be a viable solution to improving the oxidative stability of food products over storage duration. Kanatt *et al*. (1998) indicated that meat and meat products with a TBARS value of 4.34 mg MDA/kg were still acceptable for consumption. Based on TBARS analysis from this study, all the coated samples were safely within the permissible limit for consumption throughout storage. Cassava, cocoyam, and sweet potato have good antioxidant properties, emphasized in their free radical scavenging activity. This may have been responsible for the aid in the retardation of lipid oxidation in the fried samples. The current study was in agreement with the findings of Yi *et al*. (2010), Gayathri (2014), and Nguyen *et al*. (2021) who reported high bioactive components and antioxidants in root and tuber crops which were able to limit lipid oxidation and also showed radical-scavenging activities to a great extent.

The flavour analysis of alternative breaded chicken breast showed no significant differences ($p>0.05$) in flavour and overall acceptability (Figure 2).

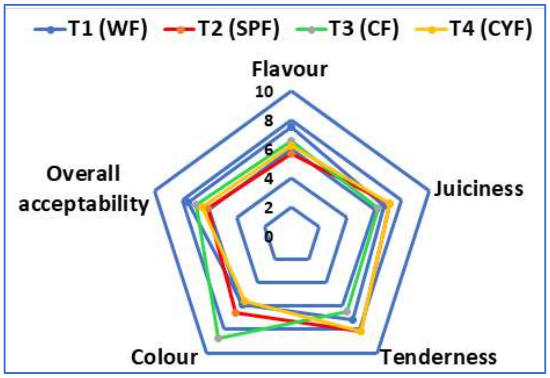

Figure 2: Flavour analysis of deep-fried chicken breast breaded with alternative coatings

However, significant differences ($p<0.05$) were observed in the breaded chicken breasts' juiciness, tenderness, and colour. Meat samples in T_3 scored the lowest values for tenderness and juiciness. The panellist's dissatisfaction with the juiciness and tenderness of the T3 samples could be linked to moisture loss resulting in the hardness. Studies by Okon *et al.* (2023) noted that the juiciness in meat emanates from the interplay of moisture released during mastication and saliva-based moisture. Hence, meat with heightened juiciness exhibits greater appeal than its less moist counterparts (Teye *et al.*, 2015). Meat in the T_3 group received the highest score for colour from the panellist. This goes further to explain consumer perception and preferences for the colour of meat and meat products, which are bright and attractive to the sight. Numerous studies have substantiated the pivotal role of colour in the palatability of meat (Park *et al.*, 2007; Van Ba *et al.,* 2012; Ekpo *et al.*, 2022; Ekpo and Okon 2023). The hue of meat is a primary gauge of its quality, wielding substantial influence over consumer perceptions and preferences. Overall, in both the control and the alternative coated groups, except for colour, the T_4 group recorded significant ($p<0.05$) attributes compared to the control.

Conclusion: The result of this study indicated that coatings prepared from locally sourced plant products could be used as a viable alternative to wheat in reducing bad cholesterol and improving the oxidative stability and flavour attributes of chicken meat. Based on the study's findings, using cocoyam flour as a coating would be a viable solution to curb the problem of the high cost of wheat flour, coupled with the lessening of consumer health complications. Additionally, more research should be carried out to improve the colour of cocoyam as a coating material to appeal to consumers.

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