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Physico-Chemical and Sensory Evaluation of Chicken Nuggets with Cooked Unripe Plantain

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ABSTRACT

Chicken nuggets were prepared with 5%, 10%, and 15% steam cooked unripe plantain without peel, and their qualities were evaluated. Linear and significantly ($P < 0.01$) increased values were observed for emulsion stability, cooking yield, moisture retention, fat retention, moisture, and total ash contents. Conversely significantly ($P<0.01$) reverse trends were observed for emulsion pH, product pH, protein and fat contents. Fiber content values were significantly increased from0.46±0.03 to 5.71±0.08%. Sensory evaluation done using nine point hedonic scale indicated that 10% cooked unripe plantain without peel resulted in higher scores for appearance, colour, flavor, juiciness, tenderness, texture and overmall palatability among the three treatments. Thus, it can be concluded that, 10% cooked unripe plantain without peel can be successfully used preparation of fiber enriched functional chicken nuggets of acceptable quality.

***Key words*:** Acceptability, Banana, Chicken, Fiber, Functional, Meat, Nuggets, Quality, Plantain

INTRODUCTION

Meat is a nutritious food which can fulfill most of the physiological and functional requirements of human body mechanisms. Poultry meat is preferred by majority of the people in our country due to lower cost, higher availability and fact that chicken meat does not have any religious taboo (Talukder and Sharma, 2010). Chicken meat has high protein content, low fat content coupled with a balanced n – 6 to n – 3 polyunsaturated fatty acids ratio, low cholesterol and presence of some of the functional components (Petracci *et al.*, 2013). Despite these nutritional advantages, chicken meat lacks dietary fiber, a crucial element for normal physiological and biochemical processes, emphasizing the significance of incorporating dietary fibers into meat products to support overall nutrition and digestive health. The inclusion of dietary fiber from diverse plant sources has the potential to mitigate the adverse effects associated with meat consumption while enhancing the nutritional composition and desirability of these products. Notably, dietary fiber's major functional properties, such as water holding capacity, gel-forming ability, and fat binding capacity, are of particular interest to meat processors (Kim et al., 2012)

Fruits, recognized as an important source of dietary fiber, include bananas, which stand out as one of the most widely distributed and consumed fruits in tropical and subtropical regions. Bananas, easily accessible to the general population. It can be consumed as cooked as well as in uncooked forms (Kookal and Thimmaiah, 2018). Bananas are known for its health benefits for humans as it's packed with nutrients similar as potassium, calcium and iron. It's also good source of filaments and vitamins, bioactive composites such as phenolic composites, and resistant bounce potentially contributing to health benefits rendering it a fit seeker for classifying it as a functional food (Vu *etal*., 2018). Recently, plantains have gained attention as a component for functional foods, particularly because of the low insipidity of plantain bounce. This property makes it an excellent component for food processing (Ming-Chang Li*et al.,* 2020). Unripe banana and banana by products are high in dietary fiber and phenolic compounds, and it has high antioxidant, antibacterial and antibiotic activities (Fidrianny and Insanu 2014: Pereira *et al*.,2020). Thus, the incorporation of plantain components in various functional foods is of interest. However, use of unripe cooked banana and ripened banana products as a source of dietary fiber in meat products is yet to be fully explored. Hence, a scientific approach was made to develop functional chicken nuggets with unripe cooked plantain without peel.

MATERIALSAND METHODS

Raw Materials

i. Chicken meat

Deboned chicken meat was purchased from the local meat stall. It was cut into small chunks and frozen for 1-2 hrs to ensure easy mincing. The chicken meat chunks were minced twice through the meat mincer and the minced meat was used in the preparation of chicken nuggets.

ii. Preparation of cooked unripe plantain

Monthan variety of plantain was used in this study. *Monthan* variety is exclusive culinary variety, widely cultivated for processing in Tamil Nadu. Fruits are large, peel is thick and pulp - firm, cream coloured, core conspicuous, medium taste. The mature unripe *Monthan* variety plantain of uniform size and shape were purchased from the local market. Before the plantain was cooked, the adhering extraneous materials on the surface were removed by using knife and washing in the running water. Then the plantain was steamed for 30 mi to an internal temperature of 80°C. The cooked plantain was peeled. The cooked plantain without peel were then shredded using a vegetable shredder and then require quantity of shredded cooked plantain without peel was used in the chicken nuggets preparation based on the formula.

Formulation and Treatments

The formula for chicken nuggets was developed after conducting a series of preliminary trails. Functional chicken nuggetsprepared with incorporation of 5, 10 and 15 % cooked unripe plantain. The corresponding levels of chicken were 68 %, 63 % and 58 % in the respective treatment. Other ingredients used in the formulation ie., common salt, sodium tri poly phosphate, dry spice mix mix (aniseed – 10, black pepper – 10, caraway seed – 10, capsicum – 8, cardamam – 5, cinnamon – 4, clove – 1, coriander – 20, cumin seed – 22, turmeric 10 in percentage/weight) ,condiments mix (onion and garlic in the ratio of 4:1), vegetable oil (Gold winner brand), refined wheat flour and ice flakes. Control chicken nuggets contained 73% chicken meat and cooked unripe plantain without peel (Table. 1).

Table 1: Formulation of functional chicken nuggets

Ingredients	C - %	Level of cooked unripe plantain (%)		
		T1 -5%	T2 - 10 %	T3 - 15 %
Chicken meat	73.0	68.0	63.0	58.0
Salt	1.5	1.5	1.5	1.5
Sodium tri poly phosphate	0.5	0.5	0.5	0.5
Dry spice mix	1.5	1.5	1.5	1.5
Condiments mix	3.0	3.0	3.0	3.0
Vegetable oil	7.5	7.5	7.5	7.5
Refined wheat flour	3.0	3.0	3.0	3.0
Ice flakes	10.0	10.0	10.0	10.0

Preparation of functional chicken nuggets

Chicken meat was partially thawed at refrigeration temperature (4±1°C) and the thawed meat was cut in to small cubes and minced in the meat mincer (Model: Primus MEW 713, Mado GmbH, Germamy) using 8 mm plate. Pre weighed quantities of salt and sodium tripolyphosphate (STPP) were added to the minced chicken meat and chopped for 2 min with a food cutter (Model TC 11, Schaefen, Germany). After addition of ice flakes, it was chopped again for 1–2 min. Refined vegetable oil was incorporated slowly and chopping was continued till the oil and fat were completely dispersed in the batter. Condiments mix, spice mix and refined wheat flour as binder were added and chopping continued for 2 min to give a fine viscous emulsion. The temperature of the emulsion varied from 10 to 12°C. The emulsion was then filled uniformly in to aluminium moulds, packed compactly and covered. The moulds were then clipped and tied and the meat blocks were cooked in a steam oven without pressure for 40 min. The internal core temperature of the cooked blocks was 80 ± 2°C measured using a probe type thermometer (Aceteq, India). The meat blocks were cooled to room temperature, chilled overnight at 4 ± 1 °C and cut into slices of 15 mm thickness using a meat slicer (ALS, India). The slices were manually cut into nuggets (1 cm x 1 cm). The fried nuggets were served immediately to a panel for evaluation of various sensory attributes on a 9 – point hedonic scale.

Physico- Chemical Analysis

i. pH

The pH of the emulsion and product samples were determined by homogenizing 10 gram of sample with 50 ml distilled water with the help of tissue homogenizer for 1 minute. The pH of the suspension was recorded by immersing the combined glass electrode of digital pH meter (Model LMPH 9Labman, India).The pH meter was pre calibrated using standard solution with pH 7.0 as per the user manual instructions, prior to measurement.

ii. Emulsion stability (%)

The method was based on the emulsion stability test reported by Baliga and Madaiah (1971) with slight modifications. 20 gram of emulsion was rolled into balls and placed in polyethylene bags. The samples were cooked at 80°C in a thermostatically controlled water bath for 20 minutes. After draining out of the exudate, the cooked mass was cooled and weighed again. The emulsion stability was calculated as percentage by using the below mentioned formula.

iii. Product yield (%)

Product yield is used to predict the yield of cooked product. The product yield was determined by the method outlined by Anna Anandh *et al* (2008). The weight of the product was recorded before and after cooking from which the cooking yield was calculated by using the following formula.

iv.Moisture retention

The moisture retention value represents the amount of moisture retained in the cooked product per 100 gm of sample and was determined according to El-Magoli et al. (1996) according to the equation below:

v. Fat retention

The fat retention value represents the amount of fat retained in the product after cooking. Fat retention was calculated according to Murphy et al. (1975) by using the equation as follows:

$$\text{Emulsion stability (\%)} = \frac{\text{Weight of emulsion after cooking}}{\text{Weight of raw emulsion}} \times 100$$

$$\text{Product yield (\%)} = \frac{\text{Weight of product after cooking}}{\text{Weight of product before cooking}} \times 100$$

$$\text{Moisture retention (\%)} = \frac{\text{\% yield x \% moisture in chicken nuggets}}{100} \times 100$$

$$\text{Fat retention (\%)} = \frac{\text{(Cooked weight) x (Fat in cooked chicken nuggets)}}{\text{(Uncooked weight) x (Fat in uncooked chicken nuggets)}} \times 100$$

vi. Proximate composition

The moisture, protein and fat contents of control and functional chicken nuggets were determined by standard methods using hot air oven, kjeldahl's assembly, soxhlet extraction apparatus and muffle furnace, respectively (AOAC, 1995). Estimation of the dietary fibre content of functional chicken meat nugget was done by using modified method prescribed by AOAC (2012).

Sensory Evaluation

Sensory evaluation was conducted with semi-trained panelists. Control and cooked unripe plantain incorporated chicken nuggets were served to the panelists. The sensory attributes like appearance and colour, flavour, juciness, tenderness, texture and overall palatability were evaluated on 9 - point descriptive scale (where in 1 is extremely undesirable and 9 is extremely desirable) as suggested by Keeton (1983).

Statistical Analysis

The experiment was repeated six times. The data generated from each trial were analyzed statistically by following standard procedures (Snedecor and Cochran, 1989) for comparing the means and to determine the effect of treatment.

RESULTS AND DISCUSSION

Physio- Chemical Characteristics

Results of physio-chemical parameters and proximate composition of chicken nuggets incorporated with different levels of cooked unripe plantain without peel (T1 - 5%, T2 - 10%, and T3 - 15%) and control (cooked unripe plantain without peel) are presented in Table are presented in Table 2.

The values for emulsion and product pH progressively and significantly (P<0.0) increased from control to cooked unripe plantain without peel incorporated chicken nuggets. Significantly (P<0.01) lower pH value was observed in T3 followed by T2, T1 and control. This trend may be attributed to the lower pH of the added green banana pulp (Izidoro *et al*., 2008), aligning with the results reported by Pereira et al. (2020) in fat-reduced frankfurters incorporated with unripe banana by-products. Carballo et al. (2021) also reported an increase in batter pH with an increase in banana pseudo-stem in pork patties.

The mean ± SE emulsion stability and product yield increased significantly from control to cooked unripe plantain without peel incorporated chicken nuggets. Among treatments, higher product yield observed in T3 followed by T2 and T1. This increase could be attributed to the fibers

Table 2. Effect of incorporation of cooked shredded unripe plantain without peel on physio-chemical properties and proximate composition of chicken nuggets (Mean ± SE)

Parameters	Level of cooked unripe plantain without peel			
	C - 0%	T1 - 5%	T2 - 10%	T3- 15%
Physio-chemical parameters*				
Emulsion pH	6.22±.00^{a}	6.16±00^{b}	6.12±0.01^{b}	6.07±0.01^{c}
Emulsion stability (%)	94.24±0.53^{a}	95.50±0.41^{b}	95.89±0.36^{b}	96.37±0.52^{c}
Cooking yield (%)	94.29±0.78^{a}	95.49±0.60^{b}	95.86±0.36^{b}	96.32±0.33^{c}
Product pH	6.31±0.00^{a}	6.24±0.00^{b}	6.19±0.01^{b}	6.15±0.00^{c}
Moisture retention (%)	57.99±0.60^{a}	59.82±0.88^{b}	61.20±0.44^{c}	62.62±0.51^{d}
Fat retention (%)	90.13±1.48^{a}	91.04±0.80^{b}	92.24±0.51^{b}	92.99±0.80^{c}
Proximate composition*				
Moisture(%)	61.51±0.40^{a}	62.65±0.70^{b}	63.85±0.57^{c}	65.02±0.48^{d}
Protein(%)	16.65±0.50^{a}	16.46±0.54^{a}	15.70±0.16^{b}	14.68±0.23^{c}
Fat(%)	20.57±0.15^{a}	19.49±0.13^{b}	18.55±0.15^{c}	17.61±0.13^{d}
Total ash(%)	2.52±0.05^{a}	2.68±0.05^{b}	2.89±0.04^{c}	3.22±0.21^{d}
Fiber content (%)	0.46±0.03^{a}	2.15±0.02^{b}	4.38±0.02^{c}	5.71±0.08^{d}

Number of observations: * = 6 Means ± SE bearing same superscripts row-wise do not differ significantly.

present in unripe banana by-products, allowing the retention of more water due to its absorption capacity (Pereira et al., 2020). The emulsion stability is directly proportional to the cocking yield percentage, which is in agreement with Pereira *et al.* (2020), who observed increased cooking yield in fat-reduced frankfurters with the addition of banana by-products obtained from unripe fruit. Similar trends were observed in bologna-type sausages formulated with green banana and pork skin gel (Alves et al., 2016).

The mean ± SE moisture retention and fat retention values of control and cooked unripe plantain without peel incorporated chicken nuggets differed significantly (P<0.01) between them and the value were significantly (P<0.01) increasing with increasing level of cooked unripe plantain without peel in the formulation. Among cooked unripe plantain without peel incorporated chicken nuggets moisture retention and fat retention were higher in T3 followed by T2, T1 and control. Pereira *et al.* (2020) reported higher retention of moisture in unripe banana flour could be an efficient ingredient with the capacity to increase water retention. The increased water retention may be explained by the dietary fiber content of cooked unripe banana. Since dietary fiber is hydrated, the pore space in fiber particles is occupied by water molecules. Higher fat retention of cooked shredded unripe plantain without peel inclusion in chicken nuggets might be due to high total fiber content in the unripe green banana flour, which form gels at high temperatures, resulting in greater retention of fat in the products (Alves *et al.,* 2016).

Proximate composition

The mean ± SE moisture content and total ash content of T3 was significantly (p< 0.01) higher as compared to other treatments. Control had significantly (p< 0.01) lower moisture and total ash contents. This is in agreement with Pereira *et al.* (2020) who reported linear increase in moisture content in frankfurters formulated with increase in unripe banana by products. Higher values of ash content of cooked shredded unripe plantain without peel incorporated chicken nuggets might be due to higher concentration of total dietary fibers, resistant starch and minerals present in the added unripe plantain (Alves *et al.,* 2016).

The mean ± SE values of protein and fat content were significantly (p< 0.01) lower in T3 followed by T2, T1 and control. Control had significantly (p< 0.01) higher protein and fat contents. Similar results were reported by Troutt *et al.* (1992) in low fat beef patties incorporated with dietary fibers at different levels. The possible decrease in the crude protein content of cooked shredded unripe plantain without peel incorporated chicken nuggets might be due to replacement of lean meat with unripe plantain which contains low protein and high carbohydrate content. Choi *et al.* (2010) who successfully decreased the fat content by adding grape seed oil and rice bran fibers as a fat substitute. Santhi and Kalaikannan (2014) also observed significant decrease in protein and fat levels with increased levels of added vegetable fibers in chicken nuggets

The mean ± SE fiber content values were 0.46±0.03, 2.15±0.02, 4.38±0.02 and 5.71±0.08 for control, T1, T2 and 15%, respectively. The 15% cooked unripe plantain without peel incorporated chicken nuggets had significantly (p< 0.01) higher fiber content than the 10%, 5% cooked unripe plantain without peel incorporated chicken nuggets and control had significantly (p< 0.01) lower among all formulation. Fiber content values between different treatments and the control differed significantly. This result aligns with Salazar et al. (2021), who observed higher fiber content in frankfurter sausages prepared with green banana products.

Sensory characteristics

Results of sensory evaluation of chicken nuggets incorporated with different levels of cooked unripe plantain without peel (T1 - 5%, T2 - 10%, and T3 - 15%) and control (cooked unripe plantain without peel) are presented in Table 2.

The mean ± SE appearance and colour scores significantly decreased from control to different level of cooked unripe plantain without peel inclusion in chicken nuggets. However, no significant difference observed between control, 5% and 10% level of inclusion and the values differed significantly from 15% level of inclusion. The mean scores ± SE for flavor, juiciness and texture were significantly (P<0.01) higher for control as compared to cooked unripe plantain without peel incorporated chicken nuggets. Among treatments, the mean score for flavor, juiciness, tenderness and texture were higher for 10% cooked unripe plantain without peel incorporated chicken nuggets followed by 5% and 15% cooked unripe plantain without peel incorporated chicken nuggets. Mean score for overall acceptability was significantly higher for control followed by 10%, 5% and 15% cooked unripe plantain without peel incorporated chicken nuggets. No significant differences observed among the treatments but values was higher for T2, but the values were non significantly higher for 10% cooked unripe plantain without peel incorporated chicken nuggets than other two level of cooked unripe plantain without peel incorporated chicken nuggets. Akaram *et al.* (2022) reported that colour scores of nuggets supplemented

Table 3. Effect of incorporation of cooked shredded unripe plantain without peel on sensory attributes of chicken nuggets (Mean ± SE)

Parameters	Level of cooked shredded unripe plantain without peel			
	C - 0%	T1 - 5%	T2 - 10%	T3- 15%
Sensory attributes**				
Appearance and colour	8.35±0.28[a]	8.27±0.30[a]	8.02±0.30[a]	7.52±0.44[b]
Flavor	8.02±0.30[a]	7.35±0.48[b]	7.72±0.75[b]	7.22±0.63[b]
Juiciness	8.12±0.27[a]	7.35±0.23[b]	7.50±0.28[b]	6.87±0.22[c]
Tenderness	7.55±0.45	7.62±0.53	7.80±0.71	7.75±0.59
Texture	8.20±0.25[a]	7.50±0.51[b]	7.45±0.39[b]	7.20±0.52[b]
Overall acceptability	8.27±0.25[a]	7.45±0.42[b]	7.65±0.40[b]	7.45±0.42[b]

Number of observations: ** = 20 Means ± SE bearing same superscripts row-wise do not differ significantly. Sensory attributes of chicken nuggets were evaluated on a 9-point descriptive scale (wherein 1 = extremely undesirable; 9 = extremely desirable).

with banana peel powder were reduced because of the dark brown colour of plantain components. These results are in agreement with Pereira et al., (2020), who reportedincorporation of unripe banana by products in frankfurters formulation improved the sensory scores of the products. Garcia *et al*. (2002) reported that the incorporation of fiber-rich ingredients led to a decrease in the sensory scores of the sausage. A similar result of decreasing sensory scores with an increasing level of banana flour was also reported by Zaini *et al.* (2021) in chicken sausages. Zaini *et al*. (2020) reported that banana peel powder in concentrations of >2% decreased the organoleptic perception of sausage. The result of the present study is in agreement with Akram *et al.,* (2022) who found that sensory evolution of broiler nuggets made with banana peel powder decreased with an increasing level in the formulation.

Based on the results of sensory attributes, chicken nuggets prepared with 10% cooked unripe plantain without peel was rated better for all sensory attributes except appearance and colour. Tenderness score between treatments and control did not differed significantly. Among treatments, the best sensory response in terms of flavour, juiciness, tenderness, texture and overall acceptability was obtained for the chicken nuggets containing 10% cooked unripe plantain without peel. The result showed that cooked unripe plantain without peel could be successfully incorporated in the preparation of functional chicken nuggets even at 10% level without any adverse effects on the physio– chemical and proximate composition of chicken nuggets.

CONCLUSION

Finding of the study suggests that incorporating cooked unripe plantain without peel in chicken nuggets has potential benefits in terms of nutritional enhancement, especially at the 10% level, without adversely affecting the overall sensory attributes. This research provides valuable insights into the development of functional meat products, considering both nutritional and sensory aspects.

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