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Quality and acceptability of functional chicken nuggets incorporated with cooked shredded whole unripe plantain

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Abstract
The purpose of the study was to develop a suitable formulation for the production of functional chicken nuggets by incorporating cooked shredded whole unripe plantain with peel at three different levels *viz.*, 2.5, 5 and 7.5%. Emulsion stability (%), cooking yield (%), moisture retention (%), fat retention (%) and total ash (%) of chicken nuggets were found to increased significantly (p<0.01) with increasing levels of cooked shredded whole unripe plantain with peel with higher values for 7.5% cooked shredded whole unripe plantain. However, emulsion pH, product pH, protein (%) and fat (%) were decreased significantly (p<0.01) with increasing levels of cooked shredded whole unripe plantain with peel. Incorporation of cooked shredded whole unripe plantain with peel represent an improvement in the nutritional value with significantly (p<0.01) higher dietary fibres in the chicken nuggets. Incorporation of cooked shredded whole unripe plantain with peel in chicken nuggets had a significant (p<0.05) persuade on sensory attributes. Based on the results of sensory attributes, the scores for overall acceptability of the chicken nuggets was significantly (p<0.01) higher for 5% cooked shredded whole unripe plantain with peel incorporated chicken nuggets and were comparable with the control. Thus, it can be concluded that, 5% cooked shredded whole unripe plantain with peel can be incorporated in the functional chicken nuggets preparation without affecting physico-chemical characteristics and sensory quality.

Keywords: Banana, chicken, fiber, functional, meat, nuggets, quality, plantain

Introduction
Chicken meat has become the most popular meat in our country due to the increase in organized marketing of chicken meat, absence of any religious taboos in its consumption, its cost advantage in comparison to other meats and increased health consciousness among consumers (Talukder and Sharma, 2010) [26]. Thus, chicken meat has played a vital role in fuelling this rapid increase in meat consumption in our nation. It is imperative to popularize processed chicken meat products and also to sustain the trend of increase in meat consumption in India. Chicken contains most of the essential amino acids, fatty acids, vitamins, and minerals that are not found in plant foods. (Petracci *et al*., 2013) [22]. However, chicken meat does not contain fibers, which are very important for normal physiological and biochemical processes Dietary fiber is an important nutrient lacking in meat products. Consumption of dietary fibre is associated with prevention of various health related disorders such as colon cancer, obesity and cardiovascular diseases (Larsson and Wolk, 2006) [17]. Therefore, the inclusion of dietary fibers from fruit sources in chicken meat products formulation increases their nutritional value.

Bananas are the world's most widespread fruit crop, grown primarily in tropical and subtropical regions, and are one of the most widely consumed fruits in the world. Bananas are considered to be the main source of sugar, vitamins, bioactive compounds and fiber which helps to minimize the risk of various chronic diseases (Vishala and Singh, 2021) [27]. Bananas have fleshy structures and are widely consumed in ripened fruit and UN ripened forms (Kookal and Thimmaiah, 2018) [15]. Bananas can also be eaten as a cooked vegetable and are called plantains (Sidhu and Zafar, 2018) [24]. Recently, plantains have gained attention as a component of functional food processing (Ming-Chang Lie *et al.*, 2020) [19].

Unripe bananas and banana by-products are rich in fiber, phenolic compounds with high antioxidant and antimicrobial properties (Fidrianny and Insanu 2014 [9], Pereira *et al*., 2020) [21]. Therefore, it is essential to incorporate plantain ingredients into various functional foods. However, the use of unripe cooked banana as a source of dietary fiber in meat products is yet explored. Hence, a scientific approach was made to develop fiber enriched functional chicken nuggets by incorporating cooked whole unripe plantain with peel.

Materials and Methods

Raw Materials

Chicken meat: Boneless chicken was purchased at a local chicken meat stall. For easy chopping the boneless chicken meat cut it into small pieces and frozen for 1-2 hours. The partially frozen boneless chicken was minced twice through meat mincer. The minced boneless chicken meat was used for preparation chicken nuggets.

Preparation of cooked unripe plantain: The mature unripe *Monthan* variety plantain of uniform size and shape were purchased from the local market. Before the plantain was cooked, the extraneous materials on the surface of the raw plantain were removed by using vegetable slicer and washed in running water. Then the plantain was steamed for 30 min until the internal plantain temperature to reach 80 °C. The cooked unripe plantain with peel was then shredded using a vegetable shredder. Based on the treatment, the required quantity of shredded cooked unripe plantain with peel was incorporated in the chicken nuggets formulation.

Formulation and Treatments: Functional chicken nuggets prepared with incorporation of 2.5, 5.0 and 7.5% cooked shredded whole unripe plantain with peel. The corresponding levels of chicken meat in the treatment were 70.5%, 68.0% and 65.5%, respectively. Common salt, sodium tri poly phosphate, dry spice mix, condiments mix, vegetable oil, refined wheat flour and ice flakes were also used in the chicken meat formulation. Control chicken nuggets prepared with 73% chicken meat without cooked unripe plantain with peel (Table 1).

Table 1: Formulation of functional chicken nuggets incorporated with cooked shredded whole unripe plantain with peel

Ingredients (%)	Level of cooked shredded whole unripe plantain with peel			
	Control	2.5%	5.0%	7.5%
Chicken meat	73.0	70.5	68.0	65.5
Cooked unripe plantain with peel	-	2.5	5.0	7.5
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

The partially frozen boneless chicken meat was cut in to small chunks and minced in the meat mincer (Model: Primus MEW 713, Mado GmbH, Germamy) using 8 mm plate. Weighed quantities of salt and sodium tripolyphosphate (STPP) were added to the minced chicken meat and chopped for 2 min in food cutter (Model TC 11, Schaefen, Germany). Refined vegetable oil was incorporated slowly and chopped till the oil and fat were completely dispersed in the batter. Then green condiments mixture, spice mixture and refined wheat flour were added and chopped for 2 min to give a fine viscous emulsion. The temperature of the emulsion maintained between 10 to 12 °C. The emulsion was then filled uniformly in to aluminum moulds, packed compactly without air gap and covered. Then the emulsion filled aluminum moulds were clipped and tied and were cooked in a steam oven the cooked blocks without pressure for 40 min to an internal temperature of 80±2 °C. The internal temperature of meat blocks were 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 chicken nuggets samples were subjected to physico-chemical analysis and sensory evaluation to select the optimum level of replacement of cooked unripe plantain and ripened banana peel powder in the functional chicken nuggets.

Physico-chemical analysis

pH: The pH of the emulsion and product samples was determined by homogenizing 10 gm of sample with 50 ml distilled water for 1 min using a tissue homogenizer. The pH of the suspension was recorded by dipping the combined glass electrode of digital pH meter (Model LMPH 9Labman, India).

Emulsion stability (%): Emulsion stability of sample was determined as per the test reported by Baliga and Madaiah (1971) [6] with slight modifications. 20 gm of emulsion was rolled into balls and placed in a polyethylene bag. The samples were boiled at 80 °C in a water bath for 20 minutes. After f the exudates was drained, the cooked mass was cooled and weighed again. The emulsion stability (%) was calculated as percentage by using the following formula.

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

Product yield (%)

The product yield was determined using the method described by Anna Anandh *et al.* (2008) [3]. The weight of the product was recorded before and after cooking, from which the cooking yield was calculated by using the following formula.

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

Moisture retention

The moisture retention (%) value represents the amount of moisture retained in the cooked product per 100gm of sample. The moisture retention (%) was determined by using the following formula as described by El-Magoli *et al.* (1996) [8]

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

Fat retention: The fat retention (%) value indicates the amount of fat remained in the product after cooking. Fat retention (%) was determined according to Murphy *et al.* (1975) by using the following formula:

$$\text{Fat retention (\%)} = \frac{\text{(Product yield) x (Fat in cooked product)}}{\text{(Uncooked product weight) x (Fat in uncooked product)}} \text{ X } 100$$

Proximate composition

The moisture, protein, fat and total ash contents of control and functional chicken nuggets were determined by using a hot air oven, kjeldahls method, soxhlet method and muffle furnace, respectively as described by AOAC (1995) [4]. Estimation of the dietary fibre content of functional chicken meat nugget was done by using modified method prescribed by AOAC (2012) [5].

Sensory Evaluation

The appearance and colour, flavour, juciness, tenderness, texture and overall palatability of control and cooked unripe plantain incorporated chicken nuggets were evaluated on 9-point descriptive scale (where in 1 is extremely undesirable and 9 is extremely desirable) by using semi-trained panelists as described Keeton (1983) [12].

Statistical Analysis

The experiment was repeated six times. The data generated from each experiment were statistically analyzed using standard procedures (Snedecor and Cochran, 1994) [25] to compare means and determine the effects of treatment.

Results and Discussion

Physico -chemical Characteristics

Results of physico-chemical properties and proximate analysis of chicken nuggets prepared with different levels of cooked shredded whole unripe plantain with peel *viz.* 2.5%, 5% and 7.5% with control are presented in Table 2.

Table 2: Effect of cooked shredded whole unripe plantain with peel on physio-chemical properties and proximate analysis of chicken nuggets (Mean±SE)

Parameters	Level of cooked shredded whole unripe plantain with peel			
	Control (0%)	2.5%	5.0%	7.5%
Physio-chemical parameters*				
Emulsion pH	6.22±0.01^a	6.15±0.00^b	6.10±0.01^c	6.05±0.00^d
Emulsion stability (%)	94.55±0.38^a	95.43±0.39^b	96.18±0.39^c	97.00±0.20^d
Cooking yield (%)	94.53±0.48^a	95.76±0.43^b	96.53±0.44^c	96.83±0.20^c
Product pH	6.30±0.01^a	6.21±0.01^b	6.16±0.00^b	6.10±0.01^c
Moisture retention (%)	57.98±0.98^a	60.81±0.27^b	63.03±0.46^c	64.46±0.34^d
Fat retention (%)	91.06±1.17^a	91.73±0.86^a	92.43±1.09^b	92.64±0.65^b
Proximate composition*				
Moisture (%)	61.34±0.96^a	63.51±0.11^b	65.30±0.46^c	66.57±0.26^d
Protein (%)	16.54±0.46^a	16.26±0.34^a	15.39±0.09^b	15.22±0.08^b
Fat (%)	20.57±0.22^a	19.43±0.20^b	18.54±0.21^c	17.51±0.15^d
Total ash (%)	2.70±0.04^a	2.82±0.02^b	2.91±0.03^b	3.11±0.07^c
Fiber content (%)	0.46±0.02^a	2.34±0.03^b	4.51±0.03^c	5.92±0.04^d

Number of observations: * = 6

Means with same superscripts in row do not differ significantly.

Emulsion and product pH values were significantly decreased from control to treatments. The pH of the emulsion and product were significantly (p<0.01) higher in control and lower in 7.5% cooked shredded whole unripe plantain incorporated chicken nuggets. Kumar *et al.* (2010) [13] also reported that significant decrease in emulsion pH with incorporation of green banana flour in chicken nuggets. The lower pH values for cooked shredded unripe plantain with peel incorporated chicken nuggets might be due to lower pH of the added crude green banana pulp. The results of pH of the present results are consistent with Barros *et al.*, (2012) [7]. They reported that pH is an indicator of the meat quality and for cooked meat products the values should be between 5.8 and 6.2.

Emulsion stability (%) and cooking yield (%) values were significantly increased with increasing levels of cooked shredded unripe plantain with peel in chicken nuggets. Higher emulsion stability was observed in 7.5% cooked whole unripe plantain incorporated chicken nuggets followed by 5.0, 2.5% cooked shredded whole unripe plantain incorporated chicken nuggets and control. The emulsion stability is directly proportional to the percentage of cooking yield and might be due to ability of cooked plantain to absorb water and emulsify fat. The results of this study were consistent with findings of Alvarez and Barbut (2013) [1] who reported that increasing the levels of soluble fibre significantly decreased the cooking loss of cooked meat. Kumar *et al.* (2013) [14] also observed increased product yield and emulsion stability in green banana flour incorporated chicken nuggets. The increased product yield and emulsion stability might be due to increased viscosity of fibers which ultimately reduces shrinkage and improved the yield of product on cooking (Lai *et al.* 2003) [16].

Moisture retention (%) and fat retention (%) values were significantly decreased from control to treatments. The moisture retention (%) and fat retention (%) values were significantly (p<0.01) higher for 7.5% cooked shredded whole

unripe plantain with peel incorporated chicken nuggets and lower value for control. The present results showed that the resistant starch and fibers content of unripe banana absorbed more water and retain on cooking (Pereira *et al.*, 2020) [21]. The increased moisture and fat retention values of cooked shredded whole unripe plantain with peel incorporated chicken nuggets might be due to higher dietary fiber content of cooked unripe plantain. Since dietary fiber are hydrated, the pore spaces of the fiber particles are occupied by water (Alves *et al.*, 2016) [2].

Moisture (%) and total ash (%) values were significantly increased from control to treatments. Moisture and total ash content for 7.5% cooked shredded whole unripe plantain with peel incorporated chicken nuggets were significantly higher followed by 5.0, 2.5% cooked shredded whole unripe plantain with peel incorporated chicken nuggets and control. Values for protein (%) and fat (%) were significantly (p<0.01) decreased in cooked shredded whole unripe plantain with peel incorporated chicken nuggets. Values for protein (%) and fat (%) control chicken nuggets were significantly higher followed by 2.5, 5.0 and 7.5% cooked shredded whole unripe plantain with peel incorporated chicken nuggets and control. The results of this study were consistent with findings of Mansour and Khalil (1999) [18] who reported that significantly (p<0.05) lower fat and protein content values in uncooked and cooked beef burgers containing wheat fibres. Alves *et al.* (2016) [2] also reported that fat content significantly decreased whereas moisture and ash content values significantly increased with increasing levels of green banana flour gel in bologna type sausages.

Fiber content values were significantly increased from control to different level of cooked shredded whole unripe plantain with peel inclusion in chicken nuggets. Fiber content values were significantly higher (p<0.01) for 7.5% cooked shredded whole unripe plantain with peel incorporated chicken nuggets and significantly lower (p<0.01) for control. The higher fiber contents of cooked shredded whole unripe plantain with peel inclusion in chicken nuggets might be due to the higher dietary fiber content of cooked plantain. These results are consistent with those of Kumar *et al.* (2013) [14] who observed that chicken meat nuggets incorporated with green banana flour had higher fiber content. Santhi and Kalaikannan (2014) [23] also observed a significant increase in fiber content in fat reduced chicken nuggets with increasing level fibers from oat.

Sensory attributes

Results of sensory analysis of chicken nuggets prepared with different levels of cooked shredded whole unripe plantain with peel *viz.* 2.5%, 5% and 7.5% with control are presented in Table 3.

Appearance and color scores were significantly decreased from control to different level of cooked shredded whole unripe plantain with peel inclusion in chicken nuggets. The mean scores for flavor, juiciness and texture were significantly (p<0.01) higher for control as compared with treatments. Among treatments, the mean score for flavor, juiciness, tenderness and texture were higher for 5% cooked shredded whole unripe plantain with peel incorporated chicken nuggets followed by 2.5 and 7.5% 7.5% cooked shredded whole unripe plantain with peel incorporated chicken nuggets. Mean score for overall acceptability was significantly higher for control followed by 5.0, 2.5 and 7.5% cooked shredded whole unripe plantain with peel incorporated chicken nuggets. The results of sensory attributes are consistent with those of Garcia *et al.* (2002) [10]. They reported that the incorporation of fiber rich ingredients reduced the sensory attributes scores of the sausage. Jakobsen *et al.* (2014) [11] observed that in reduced flavor, odor and acceptability sensory scores in fiber enriched fresh sausages with increased in firmness and grainy texture. Kumar *et al.* (2013) [14] also found that the incorporation of green banana flour reduced the sensory analysis scores of chicken nuggets.

Table 3: Effect of incorporation of cooked shredded whole unripe plantain with peel on sensory attributes of chicken nuggets (Mean ± SE)

Parameters	Level of cooked shredded whole unripe plantain with peel			
	Control (0%)	2.5%	5.0%	7.5%
Sensory attributes**				
Appearance and colour	8.27±0.25^{a}	8.10±0.30^{a}	7.25±0.38^{b}	6.80±0.69^{c}
Flavor	8.12±0.39^{a}	7.35±0.98^{c}	7.92±0.43^{b}	7.25±0.78^{c}
Juiciness	8.07±0.37^{a}	6.97±0.34^{c}	7.17±0.24^{b}	6.65±0.48^{c}
Tenderness	7.52±0.52^{a}	7.47±0.41^{a}	7.67±0.56^{a}	7.27±0.41^{a}
Texture	8.12±0.27^{a}	7.35±0.46^{b}	7.40±0.20^{b}	6.97±0.41^{b}
Overall acceptability	8.15±0.36^{a}	7.37±0.42^{b}	7.57±0.46^{b}	6.95±0.32^{b}

Number of observations: ** = 20

Means with same superscripts in row do not differ significantly.

**Sensory attributes were evaluated on a 9-point hedonic scale (Wherein 1 = extremely undesirable, 9 = extremely desirable).

Based on the results of sensory attributes, chicken nuggets prepared with 5% cooked shredded whole unripe plantain with peel was rated better for all sensory attributes except appearance and color. The sensory scores for flavor, juiciness, tenderness, texture and overall acceptability were higher for the chicken nuggets incorporated with 5% cooked shredded whole unripe plantain with peel. The result showed that cooked shredded whole unripe plantain with peel could be successfully incorporated in the preparation of fiber enriched functional chicken nuggets with 5% level without any detrimental quality characteristics of chicken nuggets.

Conclusion

Findings of this study demonstrate that 5% cooked shredded whole unripe plantain with peel can be successfully used for the preparation of fiber enriched functional chicken nuggets without compromising physico-chemical and sensory attributes with acceptable quality with improved nutritional value.

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