Original Research

Quality of Functional Chicken Nuggets Enriched with Flaxseed Flour

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Rec. Date:	May 29, 2018 06:42
Accept Date:	Jul 31, 2018 17:02
DOI	10.5455/ijlr.20180529064237

Abstract

The present study was taken up to improve the quality of chicken nuggets as functional food using flaxseed flour. The study consists of control – C and treatment groups - T_1, T_2, and T_3 containing 1, 2 and 3 percent flaxseed flour respectively. The treatment groups showed significantly higher moisture, fat, fibre and ash content when compared to control. The pH and TBARS value was lower in treatment group whereas cooking yield and emulsion stability were higher. On fatty acid profiling, linolenic acid and polyunsaturated fatty acid such as eicosapentaenoic acid and docosahexaenoic acid in treatment groups were higher when compared to control group. The ultrastructure study reveals that treatment groups showed increased fat globules size and stable protein matrix. The sensory evaluation reports of T_2 group was preferred and had significant higher sensory attributes. The microbiology study showed lower total viable count and psychrophilic count in treatment group and coliforms were absent. The study promotes the functionality of chicken nuggets incorporated with flaxseed flour which showed higher fibre, PUFA, emulsion stability, antioxidant and antimicrobial effect with good sensory acceptability.

Key words: Antioxidant, Antimicrobial, Flaxseed, Functional Food, High Fibre, Nutritive Value, PUFA

How to cite: Deepak, S., Chandregowda, C., Reddy, R., & Puttamallappa, R. (2018). Quality of Functional Chicken Nuggets Enriched with Flaxseed Flour. International Journal of Livestock Research, 8(12), 64-72. doi: 10.5455/ijlr.20180529064237

Introduction

The foods of animal origin are known for good digestibility, bioavailability and meets the protein requirements of the body. Meat act as a major source of animal food proteins, which has high biological value and provides the other vital nutrients such as minerals and vitamins but lacks fibre (Bilek and Turhan, 2009). The consumption of meat is often related to negative health effects as studied by European prospective investigation on cancer and nutrition in 2013, shown that positive association with consumption

of processed meat and cardiovascular disease, cancer and obesity (Fernandez-Gines *et al.*, 2005). The thrust area in meat science research is to reduce the unhealthy constituents of meat or to increase the health constituents in meat (Arihara, 2006; Fernandez-Gines *et al.*, 2005). The increased awareness of the consumer on nutritional content of food has led to development of healthy, novel and newer functional foods.

To improve the quality of foods of animal origin *viz*. meat and meat products with higher antioxidant potential, higher polyunsaturated fatty acids content, increased fibre content with the addition of unconventional foods with functional properties been reviewed by Decker and Park (2010). In recent review by Goyal *et al.* (2014) has mentioned that flax and flaxseed oil as an ancient medicine and a modern functional food. The flax (*Linumusitatisimum* L.) is either an oil crop or a fibre crop (Vaisey-Genser and Morris, 2003). The high level of alpha-linolenic acid (ALA), an essential omega-3 fatty acid and phytochemicals (lignan: secoisolariciresinoldiglycoside (SDG) and dietary fibre (Morris 2003) make the flaxseed as entity for functional food. Hence, there is a need for development of low cost, highly acceptable functional meat products by academicians and food industry. The present study with a concept note of addition of flaxseed as functional ingredients to chicken meat make it a functional food.

Materials and Methods

Fresh hygienically processed chicken thigh, drumstick and breast meat cuts (deboned, skin and visible fat removed manually) were obtained from local poultry processing plant (Farm Fresh Poultries, Hassan, Karnataka, India) and chilled overnight under refrigeration temperature (4 ± 1^0C). The chilled meat was first coarsely ground through a 13-mm plate followed by 8-mm plate of a meat mincer (SCHARFEN, Model X70, 58413 Witten, West Germany). Other ingredients (flaxseed, spices, condiments mix) required for preparation of emulsion were procured from local super market.

Preparation of Chicken Nuggets

Chicken emulsion was prepared using minced chicken (70%), vegetable oil (10%), ice flakes (10%), egg albumin (2%), NaCl (1.5%), binder (3.0%) and spices (3.5%) according to our laboratory standard procedures. The flaxseed flour added at different levels in treatment groups (1% flaxseed in T_1; 2% flaxseed in T_2 and 3% flaxseed in T_3) and control without flaxseed. The experiment was repeated in 3 trial at different time intervals. The emulsion is packed in nugget carrier tightly and cooked at 90-100^{0}C for 30-45 mins. or till the core temperature reaches 75^{0}C. The cooked emulsion is cooled and cut into standard nugget size and vacuum packed. The vacuum packed chicken nuggets were stored under refrigeration condition for storage study. The storage period was for 28 days and evaluation was done on 0th, 3rd, 7th, 14th and 28th day of storage duration.

 DOI 10.5455/ijlr.20180529064237

Proximate Composition and pH

Moisture, protein, fibre, ash and fat content were determined according to procedure of AOAC (AOAC 2005). The pH was determined by homogenising 10 g sample in 50 ml distilled water using mortar and pestle. The pH values were measured using a standardized electrode attached to a digital pH meter (Fisher Scientific, Model: 1.5-078-201, India).

Emulsion Stability and Cooking Yield

Cooking yield was determined as per the method of Baliga and Madaiah (1970). Cooking yield was determined by dividing cooked product weight by raw uncooked weight and multiplying by 100. Emulsion stability calculated as total fluid release (TFR)= water release (WR) + fat release (FR) which expressed as g/100 g. WR was determined as weight loss after oven drying of total released fluid for 16 h and expressed as g/100 g. Fat release (FR) was calculated as the difference between TFR and WR (Yogesh *et al.*, 2015).

Fatty Acid Profile

The fatty acid composition was estimated by gas chromatography according to AOCS Official Method Ce 1h-05 (AOCS, 2005). The lipids were extracted as per the standard procedure of Folch *et al.* (1957) and transmethylation procedures were carried out as per the method of Sukhija and Palmquist (1988). The fatty acid methyl esters were separated and quantified by gas chromatography (CHEMITO, model CERES 800 plus, India) using a fused silica capillary column of 30 m × 0.25 mm *i.e.*, 0.25 µ film thickness. Ramped oven temperature conditions (180ºC for 5 min increased to 220º C and held for 5 min) were used. Temperature of both injector and detector were 250ºC and 260ºC respectively.

Scanning Electron Microscopy

Chicken nuggets samples were fixed in 2.5% glutaraldehyde in 0.1M phosphate buffer (pH 7.2) for 24 h at 4ºC and post fixed in 2% aqueous osmium tetroxide for 4 h. Later samples were dehydrated, freeze-fractured and dried with t-butyl alcohol. The processed samples were mounted over the stubs with double-sided carbon conductivity tape, and a thin layer of gold coat over the samples was applied by using an automated sputter coater (Model: JEOL JFC-1600) and scanned under scanning electron microscope (SEM, Model: JOEL-JSM 5600) as per the standard procedures (Bozzola and Russell, 1998).

Thiobarbituric Acid Reactive Substances (TBARS)

The thiobarbituric acid reactive substances (TBARS) of cooked sausages were determined (Witte *et al.*, 1970) by blending 4 g sample with 20 ml of 20% trichloroacetic acid solution followed by centrifugation and mixing 2.0 ml of supernatant with equal volume of 0.1% thiobarbituric acid in glass test tubes and heated in water bath at 100º C for 30 min. The absorbance of the mixture was measured at 532nm using

DOI 10.5455/ijlr.20180529064237

UV-VIS spectrophotometer (Model: UV-1700 PharmaSpec, SHIMADZU, Japan), and the TBARS values were calculated using a TBA standard curve and expressed in mg malonaldehyde/kg.

Sensory Evaluation

The 10 member's panel to evaluate the appearance, colour, texture, juiciness, flavour, mouth coating and overall palatability on an 8-point hedonic scale. An eight-point descriptive scale (Keeton, 1983). The panelist were required to cleanse their palates with water between samples.

Microbiological Evaluation

The 10 g of nuggets sample was homogenized with 90 mL of 0.1% sterile peptone water. Serial 10-fold dilutions were prepared by diluting 1mL of homogenate in 9mL of 0.1% sterile peptone water. Appropriate serial dilutions were duplicate plated (Pour plate method) with plate count agar for total plate count (TPC) and psychrophilic count (PPC), potato dextrose agar for yeast and mould count (YMC) and violet red bile agar coliform count respectively. Later plates were incubated at 37^0C for 24-36 h for TPC and coliform count, 25^0C for 10 days for YMC and 7^0C for 5 days for PPC (ICMSF 1983).

Statistical Analysis

The overall experiment was replicated on three times and duplicate subsamples average used for all the parameters on statistical analysis. The experimental design was a randomized complete block design. Statistical analysis was performed with the analysis of variance using SPSS (SPSS version 13.0 for windows; SPSS, Chicago, IL, USA) and differences among mean values were obtained by Duncan's multiple range test. Significance was defined at a level of $p<0.05$ and $p<0.01$. The results were expressed as the least square mean values of three independent replications.

Results and Discussion

The proximate analysis of the plain flaxseed flour revealed moisture (6.71%), ash (3.55%), crude fat (41.3%), crude protein (25.3%), crude fibre (6.8%) and carbohydrate (16.34%). The proximate composition, pH, emulsion stability, cooking yield and emulsion stability parameters of different treatment groups are given in Table 1. The moisture level significantly increased ($P <0.05$) in all treatment groups when compared to control. Moisture content of the product depends on the fat and protein content of the product. The present results are in agreement with increased moisture level of flaxseed enriched with beef patties by Bilek and Turhan (2009). The ash concentration was significantly increased ($P <0.05$)in treatment groups which suggestive of increase mineral content with addition of flaxseed concurrent with studies of Turhan *et al.* (2005); Yogesh *et al.* (2015).The fat percentage was significantly increased ($P <0.05$) in treatment groups which are suggestive that effect of fat content of flaxseed flour similar results been

DOI 10.5455/ijlr.20180529064237

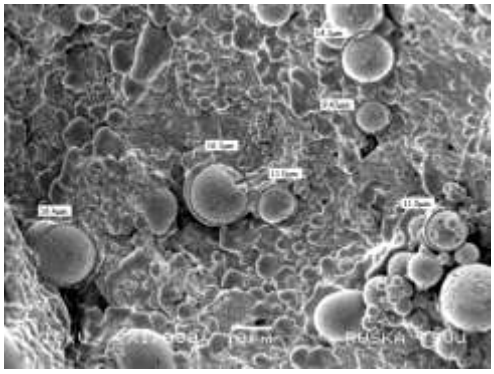
observed with beef patties enriched with flaxseed by Bilek and Turhan (2009) and chicken meat batter by Yogesh *et al.*, 2015.

Table 1: The physio-chemical parameter of chicken nuggets with various treatment regime

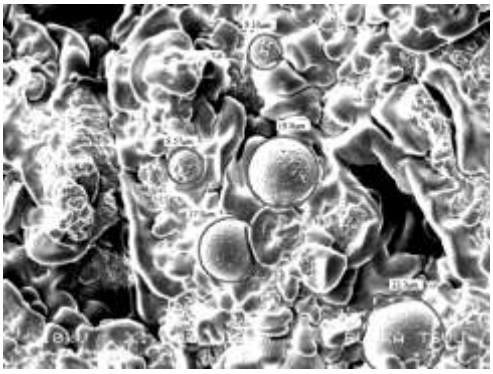
Sample code	Moisture	Ash	Fat	Protein	Fibre	pH	Cooking Yield (%)	Emulsion Stability (TFR)	Water Release (WR)	Fat Release (FR)
C	66.22± 1.04*	0.97±0.15 a	22.58±0.75*	30.10±1.15*	0.93±0.11*	5.9±0.1**	90.25*	5.75*	4.45*	1.30*
T_1	65.70± 1.55*	1.52±0.51*	22.60±0.42	31.74±1.02*	0.96±0.25*	5.9±0.1**	91.55*	5.45*	4.30*	1.15*
T_2	67.06± 2.05*	1.42±0.36*	24.23±1.25*	28.54±0.42*	1.09±0.41*	5.8±0.1**	92.84*	5.16 *	4.06*	1.10*
T_3	67.64± 1.95*	1.46±0.74*	24.03±0.91*	27.19±0.94 a	1.26±0.84*	5.8±0.1 **	92.12*	5.88*	4.33*	1.55*

** indicates level of significance at (<0.05); ** indicates level of significance at (<0.01)*

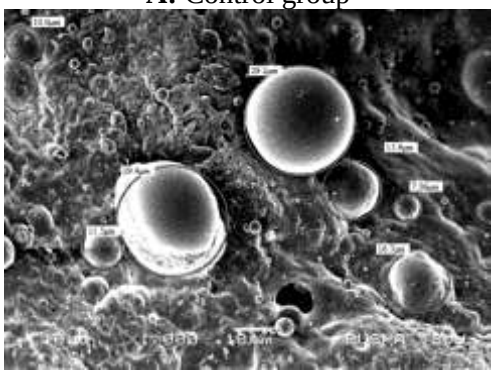
The protein content was significantly(P <0.05) decreased in treatment groups compared to control concurrent with studies of Bilek and Turhan (2009) but Yogesh *et al.* (2015) reported no effect on protein content with flaxseed enriched cooked chicken meat batter. The fibre percentage was significantly increased in treatment groups. The fat within the food matrix of meat products helps to ensure sensory quality and acceptability (Serdaroglu and Degirmencioglu, 2004).



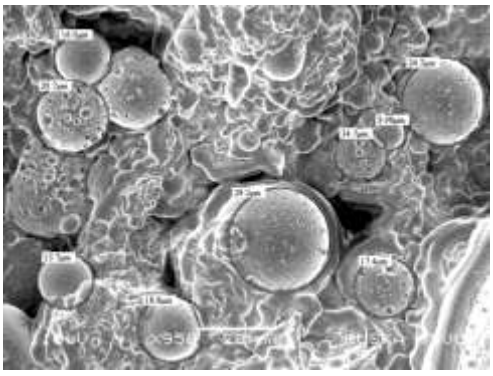
A: Control group



B: Treatment-1



C: Treatment-2



D: Treatment-3

Fig. 1: Scanning electron microscope images of chicken nuggets with various treatment regime

DOI 10.5455/ijlr.20180529064237

The pH values of the chicken nuggets have significant difference between the treatment groups ($p<0.01$) and control. Similar results been observed with Yogesh *et al.* (2015) with cooked meat batter incorporated with flaxseed powder. The cooking yield pattern is significantly higher ($p<0.05$) with treatment groups compared to control group. The loss of cooking yield decreased as the concentration of flaxseed increased due to increase in fat content. The emulsion stability was significant difference with release of TFR, WR and FR with treatment groups. Previous reports explain the emulsifying activity of flaxseed, its protein has better water and oil absorption capacity (Wang *et al.*, 2010). The fat/lipid oxidation is measured based on the reducing level of thiobarbituric acid reactive substances (TBARS). There was highly significant difference in TBARS value between storage days' study ($p<0.01$) and significant between treatment groups ($p<0.05$) and control. The antioxidant potential of flaxseed is best explained with low TBARS values of treatment groups when compared to control group.

The considerable increase in the linolenic acid content in treatment groups when compared to control group. The complete fatty acid profile of the control and treatment groups were given in Table 2. There been influence of flaxseed in improvement of fatty acid profile in meat product. The PUFA such as eicosapentaenoic acid and docosahexaenoic acid were also seen in increased as the increase in concentration of flaxseed incorporation in meat products. Similar results were obtained by Pelser *et al.* (2007) in Dutch style fermented sausages with added flaxseed oil. The scanning electron microscopy of control and treatment groups are represented in figure: 1 under 1000 magnification.

Table 2: The fatty acid profile of chicken nuggets with various treatment regime

Fatty Acid	C	T_1	T_2	T_3
Myristic Acid	0.51	0.65	0.41	0.65
Palmitic Acid	18.5	19.24	17.5	18.3
Stearic Acid	5.02	5.15	5.08	4.53
Oleic Acid	42.1	42.37	41.63	41.29
Linoleic Acid	27.92	25.78	26.48	25.08
Linolenic Acid	0.45	0.94	3.93	3.9
Arachidic Acid	0.15	0.22	0.37	0.26
BehenicAcid	0.21	0.21	0.11	0.31
Eicosapentaenoic Acid	0.24	0.25	0.3	0.71
Docosahexaenoic Acid	0.44	0.26	0.27	1.05
Palmitoleic Acid	4.09	4.14	3.62	3.54
Others	0.37	0.79	0.31	0.39
Total	100	100	100	100

The control group had a gelatinous course protein matrix with small fat globule size varied from 9.4µm to 16.4 µm and similar with findings of Carballo *et al.* (2000) who showed the microstructure of the control meat batters of freeze-thawed pork which had an open protein matrix with thick protein structure. The Treatment group had increased protein gelatinous and stable emulsion with increased fat globule size

 DOI 10.5455/ijlr.20180529064237

varying from 7.10µm to 29.4 µm thickness. The T_3 has increased the protein gelatinous but broken porous fat globules. The increased fat globules size with liquefaction and gumminess for amalgamation and more stable emulsion as demonstrated by Naveena *et al.* (2016) in sous-vide cooked chicken nuggets at varied temperature time combinations. The sensory scores of different treatment group are represented in Fig. 2.

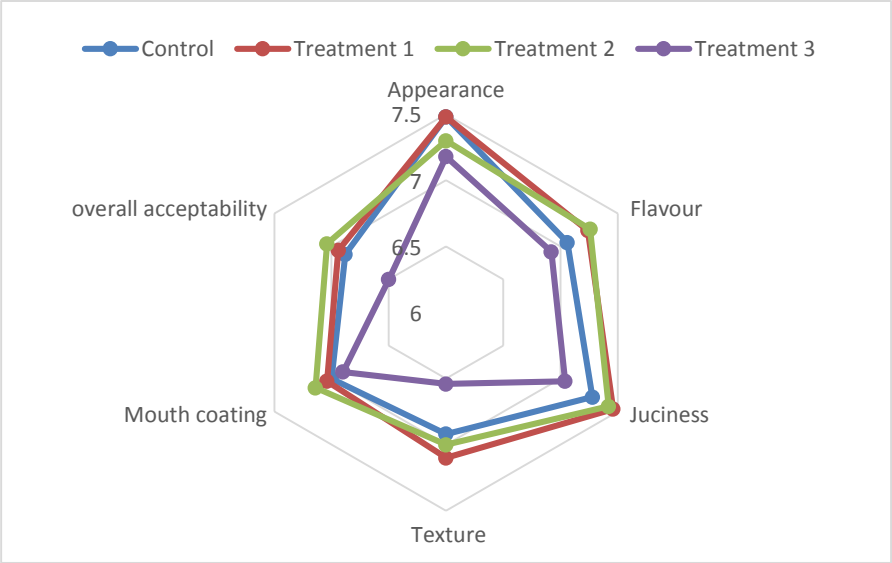


Fig. 2: Sensory evaluation report values of chicken nuggets with various treatment regime

The sensory scores for parameters such as appearance, flavour, tenderness, juiciness and overall acceptability were significantly affected (P <0.05) by the addition of flaxseed flour. The similar results were found with Bilek and Turhan (2009) in his study on beef patties with flaxseed and Turhan *et al.* (2005) studies on beef burgers with hazelnut pellicle. The total plate count (TPC) and psychrophilic count (PPC) were significantly higher (p<0.05) in control when compared to treatment groups (Fig. 3&4).

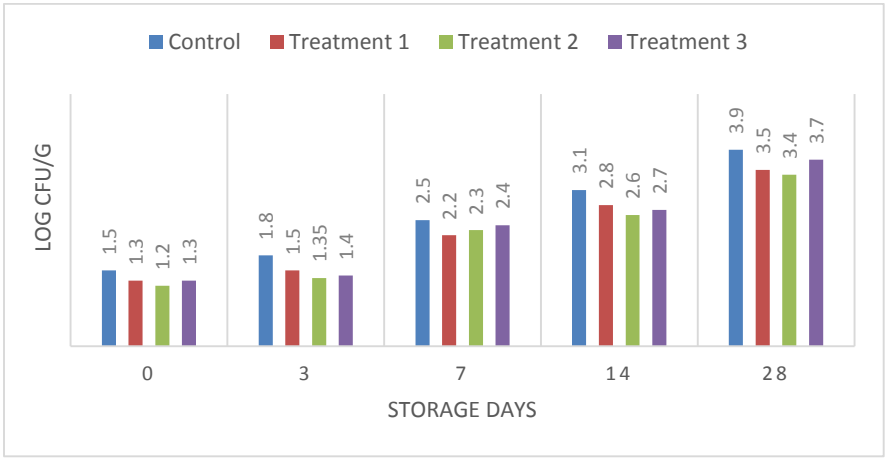


Fig. 3: The total plate count of chicken nuggets with various treatment regime

DOI 10.5455/ijlr.20180529064237

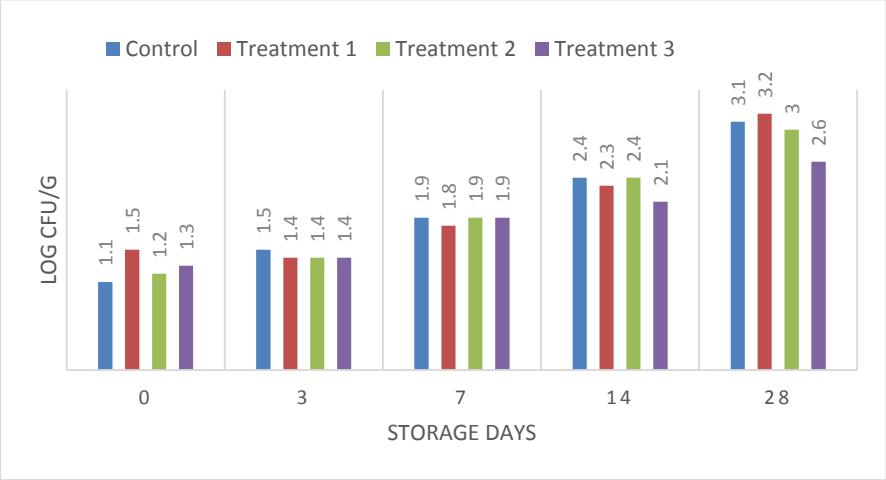


Fig. 4: The Psychrophilic count of chicken nuggets with various treatment regime

The influence of the flaxseed on decreasing the number of bacteria was observed in treatment groups. On coliform count, we did not encounter any coliform after 28 days of storage study both in control and treatment groups. There was no growth of yeast and mould up to 14 day of storage but later on 28th of study found 1.5 log CFU/g in control and 0.6-0.8log CFU/gin treatment groups which was not significant.

Conclusion

The present study concludes that addition of flaxseed flour at 2% level helps to improve the nutritional status with good sensory acceptability in development of functional chicken nuggets. The good fatty acids such as linolenic acid and PUFA -EPA and DHA are increased with incorporation of flaxseed in chicken nuggets. The ultrastructural study reveals the uniformity in fatty acid and better emulsion. The antimicrobial activity was improved with addition of flaxseed by lowering the TPC, PPC and YMC. The further studies are intended to study on animal/human trails for health benefit analysis, storage study and further validate and optimise the flaxseed incorporation level for commercial production of meat products.

Acknowledgements

Authors acknowledge support and cooperation of Dean, Veterinary College, Hassan; Ruska Lab, Veterinary College, Hyderabad; AFAQAL laboratory, VCRI, Namakkal. Study was funded by Karnataka Veterinary Animal and Fisheries Sciences University, Bidar.

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DOI 10.5455/ijlr.20180529064237