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Effect of Omega-3 Eggs and Insoluble Dietary Fibre on the Physico-Chemical, Proximate and Sensory Properties of Chicken Nuggets

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ABSTRACT

The study was aimed to select a suitable dietary insoluble fibre (DISF) for incorporating in functional chicken nuggets enriched with omega-3 eggs (OE). The wheat fibre (T_1) and sorghum fibre (T_2) at 4 per cent level were used separately as sources of DISF in the formulation and were evaluated for various physico-chemical characteristics, proximate composition and sensory properties and compared with control C_1 (without any functional ingredients) and C_2 (enriched with 7.5 per cent OE). The DISF enriched chicken nuggets differed significantly (P<0.05) from the control chicken nuggets with respect to emulsion pH, cooking yield, moisture, protein and fat content. The lightness and yellowness values were significantly higher for the T_1 and T_2 chicken nuggets but redness value was significantly lower for T_1 and T_2 than control C_1. Wheat fibre at 4.0 per cent level lowered the sensory score values. Acceptable functional chicken nuggets can be made by incorporating 7.5 per cent OE and 4.0 per cent sorghum fibre without deteriorating the nutritive and sensory qualities of the product and was comparable with controls.

Keywords: *Functional chicken nuggets, omega-3 eggs, wheat fibre, dietary insoluble fibre, sorghum fibre*

INTRODUCTION

The people are becoming health conscious due to rapid expansion of knowledge about influence of diet on health and wellbeing. The concept of food in the present era is changing drastically from the classical idea of supplying the nutrients required and of satisfying consumer expectations. Consumer interest towards food containing components that may enhance health beyond their nutritional value is hovering. The consumer demands, the high competition in the industry, research and development for new products formulation with tertiary function is highly solicited. With increase in life style diseases, consumers are deeply concerned about how their health care is managed, administered and priced. The consumers are seeking complementary or alternative beneficial products that can enhance their health and prevent diseases. The evidence from epidemiological and clinical trial data indicates that the phytochemicals or functional foods can be good alternatives. Omega-3 fatty acids are essential fatty acids that have beneficial cardiovascular properties, essential for retinal and brain development in infants, prevent autoimmune disorders, cancer of the breast, colon and prostate, and reduce the risk of rheumatoid arthritis and hypertensions (Connor, 2000; Huynh *et al*., 2023). Omega-3 fatty acids provided through animal products like omega-3 eggs and meat are thought to be more stable to the effects of processing than fats and oils added directly during food processing.

Meat products are very poor sources of dietary fibre and their regular consumption is being associated with various health disorder such as colon cancer, obesity and cardiovascular diseases (Tarrant, 1998; Larson and Wolk, 2006). However, due to changes in the food habits, lack of moderation and variety in the food consumed many never get sufficient dietary fibre required. Various reports revealed that intake of dietary fibre decrease intestinal disorders, cholesterol level and blood sugar level (Eastwood., 1992; Johnson and South gate, 1994) Incorporation of dietary fibre from different sources in meat products would help to enhance their nutritional composition and desirability. Kaur *et al.* (2022) observed incorporation of 4 per cent cauliflower stem as source of dietary fibre in spent hen meat cutlets exhibited good acceptability. Functional properties of dietary fibers such as water retention, emulsion stability, lubrication, texture modification and neutral flavour increases the suitability of their incorporation in meat products (Mehta *et al*., 2015). With this background the present study was undertaken to develop a suitable formulary for omega-3 enriched functional chicken with DISF (wheat and sorghum fibre) and observe their effect on the physicochemical, proximate and sensory properties of product.

MATERIALS AND METHODS

A. Ingredients

Broiler bird of 2 to 2.5 kg live body weight was procured from the local market and were humanely slaughtered and dressed under hygienic conditions at Meat Technology Unit, Mannuthy. The dressed carcasses were immediately chilled (4±1°C) for 12 hrs and deboned. Deboned meat was aerobically packed in high density polyethylene (HDPE) bags, chilled and used for preparation of nuggets. Other ingredients used were refined sunflower oil (Sundrop) as added fat source, the condiment paste (onion and garlic- 3:1 w/w), spice mixture consists of coriander, cumin seeds, caraway, black pepper, red chilli, anise, dry ginger, turmeric, cinnamon, cardamom, curry leaves, clove, nutmeg and mace. Curing ingredients *viz.,* Sodium chloride, sugar, sodium-tri-polyphosphate, sodium ascorbate and sodium nitrite. Omega-3 eggs (OE) containing omega-3 fatty acid 1.27g/100g (Sugana (P) Ltd., India) was added as whipped whole liquid egg in the formulation. Wheat fibre (Baggrys India Ltd) and sorghum fibre purchased from local market were used as dietary fibre source. The level of omega-3 eggs was standardized after various preliminary pilot studies.

B. Product formulation

The formulation of emulsion based chicken nuggets was standardised by conducting several trials. The standardised formulation was used for the study (Table.1).

Table 1. Formulary for the preparation of control and functional chicken nuggets

Ingredients	Control nuggets (%)	Functional chicken nuggets (%)
Ground chicken	67.5	60
Ice flakes	10	10
Vegetable oil (sunflower oil)	12	12
Condiments	4.0	4.0
Spice mix	1.7	1.7
Corn flour	1.5	1.5
Refined Wheat flour	1.5	1.5
Salt	0.9	0.9
Sugar	0.3	0.3
Sodium tripolyphosphate	0.3	0.3
Sodium ascorbate	0.3	0.3
Sodium nitrite	120 ppm	120 ppm
Omega 3 enriched egg	0.0	7.5
Insoluble dietary Fibre source	0.0	**

**Fibre sources (wheat and sorghum fibre) were added over and above the quantity of the formulation standardized with omega- 3 enriched egg as per the model design.

C. Preparation of chicken nuggets

Deboned broiler chicken was minced through a 9 mm grinder plate in a meat mincer (MADO primus Model MEW 613, Germany). The ground chicken was preblended with salt, sodium-tri-polyphosphate, sugar, sodium ascorbate and sodium nitrite at the levels given in the Table 1 and kept under refrigeration for about 12 hours. The emulsion was prepared in a bowl chopper (MADO GARANT, Germany) by chopping the pre-blended chicken for 3-5 min with simultaneous addition of ice flakes. Then whipped omega-3 whole eggs were added and chopped further for 1-2 min, followed by the addition of pre-chilled refined sunflower oil till it was evenly dispersed in the batter during chopping. Then binders corn flour and refined wheat flour 1.5 per cent each, condiments (4 per cent) and spices mix (1.7 per cent) as per formulary were added. Dietary insoluble fibre was added with the mix and chopped till uniformly dispersed with desired consistency of the batter. Six hundred gram batter was taken and manually filled in stainless steel mould under hygienic condition. The mould covered with lid was steam cooked for 40 min to get proper cooked blocks. Chicken blocks so obtained were cooled and kept under refrigeration for 12-15 hours. These blocks are sliced into nuggets of size 1.5cm x 1.5cm x 1.5cm.

D. Experiment design

The experiment was conducted to study the acceptability of DISF wheat fibre (WF) and sorghum fibre (SF) at the rate of 4 per cent separately in the formulation of chicken nuggets containing 7.5 per cent omega-3 enriched egg as shown in Table 1. The batter without OE and batter with 7.5 per cent OE were the two controls in this experiment.

C_1: Control 1 (without OE and DISF)
C_2: Control 2 (7.5 per cent OE, without DISF)
T_1: C_2+4 per cent WF
T_2: C_2+4 per cent SF

E. Product analysis

i. **Samples.** Twelve samples (triplicate in four batches) for all four types of products (control C_1, control C_2, treatments T_1 and T_2) were evaluated for various parameters such as pH, cooking yield, moisture retention and fat retention percentage and proximate composition.

ii. **pH determination.** The pH of the chicken nuggets from all the treatments and control, before and after cooking was determined using a combined electrode digital pH meter (µ pH system 362, Systronics, India) as per procedure of Troutt *et al.* (1992).

iii. **Emulsion Stability.** The emulsion stability was determined by the method of Baliga and Madaiah (1970). Twenty five grams of meat emulsion was taken in a polythene bag and heated in a thermostatically controlled water bath at 80°C for 20 min. Then the exudates were drained and the cooked mass was blotted with a tissue paper, cooled and weighed. The percentage of cooked mass was expressed as emulsion stability.

iv. **Cooking yield percentage.** The weight of meat loaves before and after cooking were recorded. Product yield was expressed in percentages.

$$\text{Product yield (\%)} = \frac{\text{Weight of the cooked block}}{\text{Weight of raw batter block}} \times 100$$

v. **Proximate analysis.** Moisture, protein, fat and ash contents of the products were determined as per the standard procedure of Association of Official Chemist (AOAC, 2016).

vi. **Calorific Value.** Total calories content of chicken nuggets were arrived at as per FAO (2002) on wet matter basis. Total calories (kcal/100g) = (fat% x 9) + (protein% x 4) + (carbohydrate % x 4).

vii. **Hunter Lab Colour (L^*a^* b^*).** Colour of the steam cooked nuggets sample was determined objectively as per Page *et al.* (2001) using Hunter Lab Mini Scan XE Plus Spectrophotometer (Hunter Lab, Virginia, USA) with diffuse illumination. The instrument was set to measure Hunter L^*, a^* and b^* using illuminant 45/0 and 10° standard observer with an aperture size of 2.54 cm. It was calibrated using black and white calibration tiles before starting of the measurement and colorimeter score recorded with 'L' of black equals zero and 'L' of white equals 100, 'a' of lower numbers equals more green (less red), higher numbers equals more red (less green) and 'b' of lower numbers equals more blue (less yellow), higher numbers equals yellow (less blue). The colour coordinates L^* (lightness), a^* (redness) and b^* (yellowness) of the samples were measured thrice and mean values were taken.

viii. **Organoleptic evaluation.** Sensory attributes of the chicken nuggets were assessed organoleptically (AMSA, 1983) using 8 point Hedonic scale, where 8= excellent; 1= extremely poor. The sensory panel consisted of seven trained taste panelists from the Department of Livestock Products Technology, Mannuthy, Thrissur. The nuggets were shallow fried in sunflower oil and served warm to the panelists with code numbers to the samples. The average of the individual scores was taken as the score for the particular attribute.

Table 2. Effect of Omega-3 eggs enriched, wheat and sorghum fibre on the physico-chemical characteristic of chicken nuggets (*n*=12)

Parameters	C_1	C_2	T_1	T_2
Emulsion pH	6.24 ±0.01^a	6.31 ±0.02^b	6.32 ±0.02^b	6.34 ±0.02^b
Product pH	6.47 ±0.03	6.51 ±0.01	6.48 ±0.02	6.52 ±0.01
Emulsion stability (%)	92.68 ±0.54^a	93.98±0.21^b	94.71 ±0.20^b	95.32 ±0.44^c
Cooking yield (%)	93.90 ±0.42^a	94.85 0.18^b	97.09 ±0.33^c	98.05 ±0.12^d

Mean ± SE with same superscripts in a row does not differ significantly (P<0.05).
C_1 - Control - 1 (without OE, DISF and AO), C_2 - Control - 2 (with 7.5% OE +0% DISF +0% AO)
T_1 – Treatment- 1 (with 7.5% OE+ 4% wheat fibre), T_2 – Treatment- 2 (with 7.5% OE+ 4% sorghum fibre)
OE-Omega- 3 eggs, DISF-Dietary insoluble fibre, AO-natural antioxidant

F. Statistical analysis

The experiment was replicated four times and the data obtained for physico-chemical, proximate composition, and organoleptic evaluation of different products were statistically analyzed using SPSS 23.0 software (Chicago, IL, USA).

RESULTS AND DISCUSSION

Physico-chemical properties

The average of the physico-chemical parameters of functional chicken nuggets incorporated with dietary insoluble fibre (DISF) and its comparison with controls are presented in the Table 2. Emulsion pH of chicken nuggets fortified with wheat fibre (T_1) and sorghum fibre (T_2) did not significantly differ with control C_2 but showed significantly (P<0.05) higher pH than control C_1.This could be attributed to neutral nature of wheat and sorghum fibre and higher pH of the added OE. These results were in agreement with those of chicken nuggets incorporated with wheat fibre (10 and 20 per cent) prepared by Kim *et al.* (2013). Emulsion stability and cooking yield of treatments significantly (P<0.05) increased with addition of DISF. Chicken nuggets with added sorghum fibre had significantly (P<0.05) highest cooking yield, followed by treatment fortified with wheat fibre. This could be due to ability of sorghum and wheat fibre to retain more water during cooking. The result of Besbes *et al.* (2008) and Mansour and Khalil (1997) are in agreement with present findings. Carvalho *et al.* (2019) reported no significant difference in the pH values and cooking losses of beef burgers on the addition of hydrated wheat fibre.

Proximate Composition and Calorie Content

The proximate composition and calorie content of the chicken nuggets are shown in (Table 3). Significant difference (P<0.05) in mean values of moisture, protein, moisture protein ratio, fat and ash content among the formulations were observed. Chicken nuggets fortified with DISF were significantly (P<0.05) higher in moisture content than the controls. This might be due to their high water holding capacity during cooking. Similar results were obtained by Fernandez-Gines *et al.* (2004) and Carvalho *et al.* (2019), whereas Troutt *et al.* (1992) noticed that moisture content was reduced in ground beef patties formulated with unhydrated sugar beet, oats and pea fibres.

Protein and fat contents were significantly (P<0.05) lower than control C_1. Protein values were corresponding to 18.28, 15.88, 14.99 per cent and fat values were corresponding to 14.71, 12.66, 12.29 per cent respectively for C_1, T_1 and T_2. Control C_1 nuggets had significantly (P<0.05) highest protein content than wheat or sorghum fibre added chicken nuggets. Kim *et al.* (2013) reported that addition of chicken skin and wheat fibre mixture significantly reduced protein content by increasing water content. Mansour and Khalil (1997) reported that crude protein was significantly (P<0.05) higher in low beef burger containing wheat fibre than control. Fat content was significantly (P<0.05) lower with wheat and sorghum fibre added chicken nuggets compared to that of controls C_1 and C_2. Declining trend in fat and protein per cent with addition of DISF may be attributed to increase in the total batter/product yield by increased moisture percentage, over addition of fibres in the treatment groups and by low fat and protein content in DISF than that of chicken. Mansour and Khalil (1997) reported that fat content was significantly (P<0.05) lower in uncooked and cooked beef burgers containing wheat fibres than control. Higher ash content in the samples fortified with insoluble fibre might be due to high mineral content in DISF.

Carvalho *et al.* (2019) observed lower protein and fat level in the beef burgers with the addition of wheat fiber. However, Mansour and Kalil (1997) and Carvalho *et al.* (2019) reported non-significant effect on ash content by addition of wheat fibre. Uikey and Nayak, (2019) found that with increase in gram hulls, the fibre content of the kadaknath chicken nuggets increased.

Calorie content significantly (P<0.05) decreased with addition of DISF compared to control and might be due to decreased fat content on addition of insoluble fibres. These results are in agreement with Hoelscher *et al.* (1987) and Osburn and Keeton (1994) who reported that calorie reduction positively correlated with fat reduction. Studies conducted by Carvalho *et al*. (2019) revealed that addition of wheat fiber to beef burgers reduced the caloric value and thus made the product a less concentrated energy source. Thus chicken nuggets with addition of DISF is considered an excellent method for calorie reduction which is important for consumers.

Product Colour

The colour attributes of functional chicken nuggets (Table 4) are expressed in terms of lightness (L*), redness (a*) and yellowness (b*) values. The L* indicating lightness value of chicken nuggets varied from 72.70 to 78.11. The lightness of the product is basically a surface characteristics and it depends on the presence of the materials/substances that reflect or absorb light. Chicken nuggets with added DISF had significantly (P<0.05) increased lightness (L*). This shows that addition of insoluble dietary fibre improve the light reflectance and thereby the brightness of the product. The b* values indicating yellowness or blueness of the chicken nuggets varied from 34.96 to 36.89. Chicken nuggets with added DISF had significantly (P<0.05) increased yellowness (b*) but reduced redness (a*) value compared to control. Reduced redness value on addition of DISF might be attributed to dilution of meat pigment concentration leading to decrease in the redness value. Addition of hazelnut pellicle in beef burgers (Turhan *et al.*, 2005) and rice bran in meat batter (Choi *et al.*, 2007) reduced brightness (L*) and yellowness (b*) value, but increased redness (a*) values than control and the colour of the fibres used in this study was pale and slightly creamy in nature.

Sensory characteristics

Mean sensory scores of chicken nuggets incorporated with dietary insoluble fibre are shown in Table 5. Ratings by the

Table 3. Effect of Omega-3 enriched eggs, wheat and sorghum fibre on the colour of chicken nuggets proximate composition and calorie of chicken nuggets (n=12)

Parameters	C_1	C_2	T_1	T_2
Moisture (%)	57.44 ±0.43^a	62.10 ±0.23^b	63.44 ±0.21^c	64.34 ±0.15^d
Protein (%)	18.28 ±0.80^a	15.70 ±0.61^b	15.88 ±0.80^b	14.99 ±0.48^b
Moisture protein ratio	3.18 ±0.28^a	3.96 ±0.24^b	4.02 ±0.37^b	4.28 ±0.25^b
Fat (%)	14.71 ±0.71^a	13.30 ±0.18^b	12.66 ±0.17^c	12.29 ±0.16^c
Ash (%)	1.98 ±0.01	2.02 ±0.03	2.05 ±0.03	2.08 ±0.05
Carbohydrate (%)	7.13 ±0.36	6.81 ±0.99	5.78 ±0.56	6.53 ±0.61
Calorie (kcal/100 g)	234.14 ±1.58^a	210.53 ±2.90^b	202.00 ±1.24^c	197.64 ±1.65^c

Mean ± SE with same superscripts in a row does not differ significantly (P<0.05).
C_1 - Control - 1 (without OE, DISF and AO), C_2 - Control - 2 (with 7.5% OE +0% DISF +0% AO)
T_1 – Treatment- 1 (with 7.5% OE+ 4% wheat fibre), T_2 – Treatment- 2 (with 7.5% OE+ 4% sorghum fibre)
OE-Omega- 3 eggs, DISF-Dietary insoluble fibre, AO-natural antioxidant

Table 4. Effect of Omega-3 eggs, wheat and sorghum fibre on the colour of chicken nuggets (n=12)

Parameters	C_1	C_2	T_1	T_2
L* (lightness)	72.70 ±0.71^a	77.24 ±0.43^b	78.11±0.70^b	77.53 ±0.35^b
a* (redness)	10.07 ±0.28^c	9.31 ±0.14^b	8.42 ±0.11^a	9.14 ±0.22^b
b* (yellowness)	34.96 ±0.23^a	36.47 ±0.35^b	36.89±0.34^b	36.35±0.40^b

Mean ± SE with same superscripts in a row does not differ significantly (P<0.05).

C_1 - Control - 1 (without OE, DISF and AO), C_2 - Control - 2 (with 7.5% OE +0% DISF +0% AO)
T_1 – Treatment- 1 (with 7.5% OE+ 4% wheat fibre), T_2 – Treatment- 2 (with 7.5% OE+ 4% sorghum fibre)
OE-Omega- 3 eggs, DISF-Dietary insoluble fibre, AO-natural antioxidant

Table 5. Effect of Omega-3 eggs, wheat and sorghum fibre on the sensory attributes of chicken nuggets (n=12)

Parameters	C_1	C_2	T_1	T_2
Appearance & colour	6.76 ±0.10	6.86 ±0.13	7.00 ±0.17	6.76 ±0.17
Flavour	6.71 ±0.10^{ab}	6.86 ±0.14^{a}	6.38 ±0.22^{b}	6.52 ±0.11^{ab}
Juiciness	6.62 ±0.11^{ab}	6.88 ±0.14^{b}	6.38 ±0.16^{a}	6.52±0.11^{ab}
Texture	6.81 ±0.13^{a}	6.93 ±0.14^{a}	6.57 ±0.18^{b}	6.71 ±0.16^{ab}
Saltiness	6.33 ±0.14^{a}	6.76 ±0.10^{b}	6.76 ±0.12^{b}	6.83 ±0.17^{b}
Mouth coating	6.57 ±0.13	6.76 ±0.14	6.71 ±0.18	6.81 ±0.16
Overall acceptability	6.57 ±0.13^{a}	7.00 ±0.12^{b}	6.33 ±0.19^{a}	6.86 ±0.19^{b}

Mean ± SE with same superscripts in a row does not differ significantly (P<0.05)
*Based on 8-point Hedonic scale (1=extremely undesirable; 8 = extremely desirable)
C_1 - Control - 1 (without OE, DISF and AO), C_2 - Control - 2 (with 7.5% OE +0% DISF +0% AO)
T_1 – Treatment- 1 (with 7.5% OE+ 4% wheat fibre), T_2 – Treatment- 2 (with 7.5% OE+ 4% sorghum fibre)
OE-Omega- 3 eggs, DISF-Dietary insoluble fibre, AO-natural antioxidant

sensory panel showed no significant difference for general appearance and mouth coating between groups whereas flavor, juiciness, texture, saltiness and overall acceptability were significantly (P<0.05) affected by the fibre types.

The general appearances of samples fortified with DISF were comparable with controls. The flavour scores of chicken nuggets incorporated with DISF was significantly (P<0.05) lower than controls. It might be due to dilution of desirable meaty flavour with added fibre and decrease in fat level in DISF fortified chicken nuggets which might have caused a reduction in flavour intensity. These results are in accordance with findings of Troutt *et al.* (1992) in low fat beef sausage extended with oats bran. Huang *et al.* (2011) reported that wheat fibre added at 3.5 per cent level in Chinese style sausage scored significantly higher for flavour than at 7 per cent.

Nuggets with fortified dietary insoluble fibre had significantly (P<0.05) lower juiciness score than controls but had significantly (P<0.05) higher score for moisture percentage (Table 5). This result indicate that though DISF had increased ability for moisture retention of the product during cooking, the products were less juicy and might be due to low release of bound water on chewing making the product to feel dry than controls. Similar observations were made by Troutt *et al.* (1992) in cooked beef patties added with dehydrated 3.5 per cent sugar beet, oats and pea fibres and Turhan *et al.*(2005) in low fat beef burger added with hazel nut pellicle.

The texture score followed a declining trend like that of juiciness with addition of DISF in the formulation of functional chicken nuggets. Panelists identified decreased softness in texture with DISF added formulation which was more pronounced in treatment with wheat bran. Garcia *et al.* (2002) and Fernandez-Gines *et al.* (2004) reported similar findings by addition of various dietary fibres in different meat products.

Saltiness score significantly (P<0.05) increased with addition of DISF in the treatments compared to control C_1 and was not significantly different with C_2. It might be due to dilution of saltiness by addition of OE and DISF. The mouth coating score for samples fortified with DISF did not significantly differ from the unfortified control. The overall acceptability scores ranged from 6.33 to 7.00 with maximum acceptability score among treatments obtained for chicken nuggets incorporated with sorghum bran and significantly (P<0.05) lowest score for wheat bran added chicken nuggets. Whereas, Mansour and Khalil (1997) reported that that the overall acceptability of low fat beef burgers was not affected by addition of wheat fibre.

CONCLUSION

The addition of dietary insoluble fibre improved the emulsion stability and cooking yield in the omega-3 enriched functional chicken nugget and sorghum fibre (4 per cent) was more acceptable than wheat fibre (4 per cent) for inclusion as DISF in chicken nuggets. Acceptable functional chicken nuggets can be prepared by incorporating 7.5 per cent OE and 4.0 per cent sorghum fibre without affecting the nutritive and sensory qualities of the product.

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COMPETING INTERESTS

The authors do not have any competing interests among themselves or others related to this research work.

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