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Quality Characteristics of Functional Chicken Meat Sausages Enriched With Omega-3-Fatty Acids

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ABSTRACT

Background: Limited information is available on the enrichment of omega-3 fatty acids and their stability in poultry products during their processing and preservation. Keeping this on view, the present study was undertaken to develop chicken meat sausages enriched with omega-3 fatty acids by incorporation of flax seed oil at different levels.

Methods: The present investigation on standardization of the different levels of flax seed oil (2, 4 and 6%) on various physico-chemical, proximate, omega-3-fatty acid profile and sensory scores of functional chicken meat sausages was investigated. The developed functional chicken meat sausages were analyzed for various quality characteristics like physico-chemical (cooking yield, emulsion stability, water holding capacity, pH and hardness and proximate composition, omega-3-fatty acid profile and sensory evaluation.

Result: Chicken meat sausages added with 6% flax seed oil (T3) had significantly ($P<0.05$) higher cooking yield, emulsion stability, water holding capacity, protein and fat than control and remaining formulations. In the same line, chicken meat sausages added with 6% flax seed oil (T3) had lower SFA values and higher MUFA values, n-6 PUFA and n-3 PUFA values, n6 PUFA/n3 PUFA ratio and PUFA/SFA ratio and superior sensory scores than control and other formulations. The addition of flax seed oil to chicken meat sausages improved the healthy fatty acid profile.

Key words: Chicken meat sausages, Flax seed oil, Omega-3-fatty acids, Quality characteristics.

INTRODUCTION

Omega-3 fatty acids (n-3) are a group of polyunsaturated fatty acids (PUFA) which include α-linolenic acid (ALA, C18:3 n-3), its long chain metabolites eicosapentaenoic acid (EPA, C20:5 n-3) and docosahexaenoic acid (DHA, C 22:6 n-3). Humans can synthesize EPA and DHA through desaturation and elongation of ALA (Bhaskar Reddy *et al.* 2018). These essential fatty acids are vital relation to human health and disease prevention such as cardiovascular diseases, hypertension, diabetes, arthritis, other inflammatory diseases and autoimmune disorders. Major sources of ALA include the seeds and oils of flaxseed, soybean and canola, with flaxseed containing 50-60% ALA (Moghadasian, 2008). Meat and meat products were excellent sources for fat, protein, essential amino acids, minerals and vitamins which were important components of the diet of individuals living in the developed countries. Various value added meat products such as sausages found to be enriched with omega-3 fatty acids has great importance to consumer well being. Sausages made from pigs fed ALA and chicken frankfurters from chickens fed fish oil at 2-4% had increased levels of n-3 fatty acids (Lee *et al.* 2015). Another approach for omega-3 PUFA enrichment of meat products is introduction of omega-3 oils as an ingredient. The modification of the ratio of fatty acids in meat products were achieved by replacement of animal fat with vegetable oils as vegetable oils were a rich source of PUFAs (Jimenez-Colmenero, 2007). Also, inclusion of oils such as fish oil results in omega-3 enrichment of meat products. It is proposed to enrich chicken meat with omega-3-fatty acids to enhance nutritional aspects of chicken. Till now very limited attempts were made for development of omega-3 fatty acids enriched chicken meat products in India. Hence, the present study was aimed to develop chicken meat sausages enriched with omega-3 fatty acids by addition of flax seed oil at different levels. The study had provided insight regarding the interaction of meat proteins from chicken with vegetable flours and oils and information on the quality characteristics of chicken meat products.

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MATERIALS AND METHODS

The study was conducted in Department of Livestock Products Technology, College of Veterinary Science, Sri Venkateswara Veterinary University, Tirupati, Andhra Pradesh from November 2017 to September 2018.

Processing of functional chicken meat sausages

Fresh broiler boneless chicken meat, flax seed oil and other non-meat ingredients were procured from local market of Tirupati. Analytical grade chemicals and food grade additives were procured from standard companies. The fresh broiler boneless chicken meat was made into small chunks and minced in a meat mincer (Sirman, TC 12 E, Italy) through 4 mm plate. The emulsion was prepared by chopping the minced meat along with other non-meat ingredients in a bowl chopper (Scharfen, Model No: TC 11, Germany). The minced chicken meat was mixed with 1.5% salt, 0.4% STPP, 150 ppm sodium nitrate, 500 ppm sodium ascorbate, 1% sugar, and 8% ice flakes and chopped for one minute. To this 6% oil was added and again chopped for one minute and added 3% corn flour, 1.6% spice mix, 3% condiment mix (onion and garlic: 3:1). To this chopped batter, flax seed oil was added at a level of 0, 2, 4 and 6 per cent in control, T1, T2 and T3 respectively by replacing lean meat and make it 100% volume and finally chopped for 3 minutes. The temperature of the emulsion was maintained between 12 to 15°C thought out the chopping process. The emulsions of control, T1, T2 and T3 were separately stuffed in fibrous casings with help of horizontal sausage stuffer (Model Sirman) and cooked for 30 minutes to an internal temperature of 75±2°C as indicated by the temperature probe. The cooked sausages were immediately chilled and subjected for various quality attributes like physico-chemical characteristics, proximate composition, fatty acid profile and sensory characteristics.

Analysis of quality characteristics

Physico-chemical characteristics

Per cent cooking yield of the final product was determined by calculating the weight difference of samples before and after cooking. Emulsion stability was determined as per Kondaiah *et al.* (1985) and Water-holding capacity (WHC) was determined according to Wardlaw *et al.* (1973) and expressed as % WHC. The pH of samples were determined by homogenizing 10 g of sample with 50 ml distilled water with the help of tissue homogenizer (Daihan Scientifics, WiseMix, HG-15D, Korea) for 1 min. The pH was recorded using micro controlled based pH system with electrode (Model: 361, Systronics, India). The hardness of the nuggets was measured in terms of penetration value with the help of cone penetrometer as described by Dixon and Parech (1979).

Proximate composition

The moisture content was determined by hot air oven drying, protein by automatic Kjeldahl method, fat by Soxhlet extraction with petroleum ether and total ash by muffle furnace as described in AOAC (2002).

Fatty acid profile

To study the fatty acid profiles, total lipids extracted from meat sample as per Folch *et al.* (1957) and dissolved in 10 ml of heptane. Five ml of heptane solution was taken and 5 ml of 2N methanolic Potassium hydroxide was added to it. Test tubes were inverted twice and heated to develop fatty acid methyl esters (FAMES). The supernatant was injected directly into gas chromatograph for separation of fatty acid methyl esters (FAMES). Thermo focus fas chromatograph fitted with a DB225 polar column (30 m, 0.322 mm, 0.251) and Flame Infrared Detector was used for the analysis of omega-3-fatty acid composition. The temperatures of oven, injector and detector blocks were maintained at 210, 230 and 250°C respectively. Nitrogen was used as the carrier gas. Peaks were identified by comparison with relative retention times (RT) of standard FAMES. Concentration of each omega-3-fatty acid was recorded by normalization of peak areas using GC post run analysis software, manual integration and reported as % of the particular fatty acid.

Sensory characteristics

The chicken meat sausages were served to trained panelists and evaluated for appearance, flavour, juiciness, tenderness and overall palatability by using a 8-point descriptive scale (8-extremely desirable, 1- extremely undesirable) as described by Keeton, (1983) with slight modifications. Sensory evaluation conducted between 3.30-4.00 PM and filtered tap water was provided to the panelists for rinsing their mouth in between evaluation of different samples.

Statistical analysis

The experiments were repeated six times and the data (for physico-chemical, proximate composition and omega-3-fatty acid profiles "n" is 6 and sensory parameters "n" is 24) was analyzed using General Linear Model procedure of statistical package for social sciences (SPSS) 22 version and compared the means by using ONE WAY ANOVA.

RESULTS AND DISCUSSION

Physico-chemical characteristics

Addition of different levels of flax seed oil (FO) significantly ($P<0.05$) influenced the various physico-chemical characteristics of chicken meat sausages (Table 1). As the level of incorporation of FO increased from 0 to 6 per cent, cooking yield was gradually increased from 84.03 to 90.08%. Bilek and Turhan (2009) noted that cooking yield was increased as the concentration of flax seed addition from 0 to 15 per cent in beef patties. Chicken meat sausages extended with 6 per cent FO (T3) had significantly ($P<0.05$) higher per cent emulsion stability than control and other treatments. The possible interaction between soluble meat and flax seed oil has been indicated to increase fat agglomeration while improving stability during emulsion matrix (Mir Salahuddin and Kondaiah, 1991). Generally vegetable oils reported to stabilize the emulsion through emulsifying and fat encapsulating properties. The results are in agreement with Bhaskar Reddy *et al.* (2018) in chicken nuggets extended with flax seed flour.

The mean water holding capacity (WHC) of chicken meat sausages incorporated with 6 per cent FO (T3) was significantly (P<0.05) higher than control and other formulations. This might be due to formation of thermo-reversible gels by flax seed oil and formation of water-oil-protein matrix. Addition of different levels of FO did not significantly (P>0.05) affect the pH values of chicken meat sausages. The addition of flax seed oil significantly (P<0.05) influenced the hardness values of chicken meat sausages. The flax seed oil added sausages had significantly (P<0.05) higher hardness values than control but there was no significant (P>0.05) difference between flax seed oil added sausages. Similar pattern of results are confirmed by the Baek *et al.* (2016) in spent layer hen emulsion sausages enriched with canola and flax seed oil.

Proximate composition

The influence of different levels of flax seed oil (FO) incorporation on proximate composition of functional chicken sausages was presented in Table 2. Addition of different levels of FO significantly (P<0.05) reduced the moisture content of chicken meat sausages. Lee *et al.* (2015) obtained related findings to replacing pork fat with vegetable oils and found that the substitution decreased the moisture content of pork sausage. The protein content in chicken meat sausages increased significantly (P<0.05) with the increased level of FO. The higher protein content in FO added sausages might be due to formation of thermo stable bonds between the oil and protein in meat emulsion matrix thus prevented the protein losses during cooking. These results are in agreement with Turp and Serdaroglu (2008) on the replacement of the added fat with hazelnut oil in the Turkish fermented sausages. The fat content of chicken meat sausages added with different levels of FO increased significantly (P<0.05) than control which might be due to direct addition of FO to the emulsion matrix. The indigenous and crossbred pigs also affect the proximate composition of finished product (Thomas *et al.* 2016). These results are in agreement with Baek *et al.* (2016) in spent layer hen emulsion sausages enriched with canola and flax seed oil. The source of meat also significantly influenced the proximate composition of finished product and there was significant difference (P<0.01) in the proximate composition among the three native breeds muscle tissues (Gnanaraj *et al.* 2020). Per cent total ash content did not significantly (P>0.05) affected by the addition of various levels of flax seed oil.

Fatty acid profile

The fatty acid composition of chicken meat sausages influenced by addition of various levels of FO was presented in Table 3. Addition of FO significantly (P<0.05) influenced both saturated, mono unsaturated and poly unsaturated fatty acid composition in chicken meat sausages. In the chicken meat sausages formulated with different levels of FO, the predominant saturated fatty acids (SFA) were palmitic (C16:0) and stearic acid (C18:0), the most abundant monounsaturated fatty acid (MUFA) was C 16:1 and C 18:1 n-9 and the predominant polyunsaturated fatty acids (PUFA) were C18:2 n-6 and C 18:3 n-3. Generally, the higher SFA

Table 1: Physico-chemical characteristics of functional chicken sausages added withdifferent levels of flax seed oil* (Mean±S.E).

Physico-chemical characteristics	Control	T1	T2	T3
Cooking yield (%)	84.03±0.17^{d}	85.42±0.14^{c}	87.10±0.27^{b}	90.08±0.08^{a}
Emulsion stability (%)	83.55±0.33^{d}	84.69±0.22^{c}	85.55±0.10^{b}	88.60±0.13^{a}
Water-holding capacity (%)	40.25±0.20^{d}	43.10±0.13^{c}	45.18±0.11^{b}	48.25±0.27^{a}
pH	5.96±0.11	5.98±0.17	5.89±0.13	5.94±0.11
Hardness value (mm)	34.29±0.19^{b}	35.09±0.14^{a}	34.98±0.20^{a}	35.08±0.09^{a}

Mean values within row bearing different superscripts are differ significantly (P<0.05).* n=6.

T1-Chicken sausages added with 2% FO.

T2- Chicken sausages added with 4% FO.

T3- Chicken sausages added with 6% FO.

Table 2: Proximate composition of functional chicken sausages added with different levels of flax seed oil* (Mean±S.E).

Proximate composition (%)	Control	T1	T2	T3
Moisture (%)	68.28±0.19^{a}	67.12±0.08^{b}	67.05±0.25^{b}	64.39±0.17^{c}
Protein (%)	18.91±0.26^{d}	19.23±0.13^{c}	20.09±0.17^{b}	21.17±0.08^{a}
Fat (%)	5.10±0.21^{d}	7.89±0.31^{c}	9.57±0.13^{b}	11.91±0.25^{a}
Total ash (%)	2.12±0.10	2.09±0.15	2.15±0.21	2.10±0.17

Mean values within row bearing different superscripts are differ significantly (P<0.05). * n=6.

T1-Chicken sausages added with 2% FO.

T2- Chicken sausages added with 4% FO.

T3- Chicken sausages added with 6% FO.

contents were found for control sausages and addition of FO decreased the SFA content of chicken sausages. The lower amount of palmitic and stearic acid in FO were responsible for this effect. While the MUFA contents of chicken meat sausages was significantly (P<0.05) affected by addition of FO.

Addition of 6 per cent FO (T3) had recorded significantly (P<0.05) higher MUFA content than control and other treatments. The highest PUFA contents were determined for chicken sausages added with 6 per cent FO and these values were significantly (P<0.05) higher than control and other formulations. The range of n-6 PUFA contents in sausages added with FO were 21.95 to 30.23. PUFA contents significantly increased as the FO level increased (P<0.05) due to the high amount of C18:2 n -6, C 20:4 n-6 and C 18:3 n-3 in FO. The chicken sausages added with 6 per cent FO (T3) recorded higher n-6/n-3 ratios than control and other formulations. The n-6/n-3 ratio ranged from 3.58 to 6.08 in FO added sausages. The addition of FO to chicken meat sausages improved the healthy fatty acid profile. Several studies indicate that the n6/n3 PUFA (Ratio) influences in the level of nutrient metabolization in the body, and as the proportion increases a smaller deposition of lipids. Different cross bred pigs also showed differences in fatty acid profile of fattener pigs (Thomas *et al.* 2019). Cheong *et al.* (2010) reported that replacing lard with enzymatic interesterified rapeseed oil increased the UFA/SFA ratio from 1.47 to 2.84, which effectively reduced the risk of cardiovascular disease.

Sensory characteristics

Sensory scores for colour, tenderness, juiciness and overall acceptability were significantly affected (P<0.05) by the addition of FO in chicken meat sausages (Table 4).

Table 3: Fatty acid composition of functional chicken sausages added with different levels of flax seed oil* (Mean±S.E).

Fatty acid composition (%)	Control	T1	T2	T3
C12:0	0.022	0.019	0.020	0.024
C14:0	0.61	0.59	0.57	0.60
C15:0	0.08	0.07	0.09	0.08
C16:0	18.25^{a}	17.15^{b}	16.20^{c}	16.25^{c}
C17:0	0.18	0.15	0.16	0.19
C18:0	9.20^{a}	8.42^{b}	7.56^{a}	6.12^{b}
C20:0	0.21	0.19	0.17	0.20
C22:0	0.03	0.04	0.04	0.03
C24:0	0.025	0.023	0.027	0.024
Total SFA	28.61^{a}	26.65^{b}	24.84^{c}	23.59^{d}
C14:1	0.17	0.16	0.15	0.16
C16:1	4.87^{b}	5.12^{a}	5.20^{a}	5.19^{a}
C18:1 n-9	30.15^{d}	33.51^{c}	35.67^{b}	36.19^{a}
C20:1	0.27	0.24	0.26	0.23
C24:1	0.17	0.15	0.18	0.17
Total MUFA	35.63^{d}	39.18^{c}	41.46^{b}	41.94^{a}
C18:2 n-6	20.52^{d}	25.42^{c}	26.83^{b}	27.88^{a}
C18:3 n-6	0.15	0.13	0.17	0.15
C20:2 n-6	0.28	0.25	0.28	0.29
C20:3 n-6	0.31	0.33	0.29	0.34
C20:4 n-6	0.70^{d}	0.99^{c}	1.23^{b}	1.57^{a}
Total n-6 PUFA	21.95^{d}	27.12^{c}	28.80^{b}	30.23^{a}
C18:3 n-3	2.23^{d}	5.12^{c}	5.67^{b}	6.99^{a}
C20:3 n-3	0.047	0.045	0.049	0.047
C20:5 n-3	0.31	0.30	0.33	0.32
C22:5 n-3	0.22	0.23	0.22	0.25
C22:6 n-3	0.80	0.87	0.83	0.85
Total n-3 PUFA	3.61^{d}	6.57^{c}	7.10^{b}	8.46^{a}
n6/n3 PUFA (Ratio)	6.08^{a}	4.13^{b}	4.06^{b}	3.58^{c}
PUFA/SFA (Ratio)	2.14^{d}	2.73^{c}	3.10^{b}	3.41^{a}

Mean values within row bearing different superscripts are differ significantly (P<0.05).* n=6

SFA-Saturated fatty acids; MUFA-Mono unsaturated fatty acids; PUFA-Poly unsaturated fatty acids.

T1-Chicken sausages added with 2% FO.

T2- Chicken sausages added with 4% FO.

T3- Chicken sausages added with 6% FO.

Table 4: Sensory characteristics of functional chicken sausages added with different levels of flax seed oil* (Mean±S.E).

Sensory characteristics	Control	T1	T2	T3
Colour	6.56±0.13[d]	6.89±0.15[c]	7.23±0.10[b]	7.56±0.25[a]
Flavour	6.93±0.17	6.90±0.08	6.87±0.12	6.93±0.27
Juiciness	6.32±0.20[c]	6.71±0.15[b]	6.98±0.14[a]	7.18±0.25[a]
Tenderness	6.30±0.20[c]	6.78±0.11[b]	7.05±0.17[a]	7.29±0.10[a]
Overall acceptability	6.17±0.08[c]	6.63±0.27[b]	7.11±0.25[a]	7.42±0.17[a]

Mean values within row bearing different superscripts are differ significantly (P<0.05).* n=24.

T1-Chicken meat sausages added with 2% FO.

T2- Chicken meat sausages added with 4% FO.

T3- Chicken meat sausages added with 6% FO.

Generally, the higher sensory scores were recorded for the 6% added FO chicken meat sausages than control and other formulations. The flavour scores of chicken meat sausages were non-significantly (P>0.05) affected by addition of FO. The range of flavour scores from 6.87 to 6.93 was observed. Juiciness, tenderness and overall acceptability scores significantly (P<0.05) affected by addition of FO. With the increased concentration of flax seed oil, the juiciness, tenderness and overall acceptability scores of chicken meat sausages were increased gradually. Chicken sausages added with 6 per cent flax seed oil (T3) had significantly (P<0.05) higher juiciness, tenderness and overall acceptability scores than control and remaining formulations. The higher scores in 6 per cent FO added chicken meat sausages (T3) might be due to higher emulsion stability and water holding capacity which contributed to more juiciness and tenderness thus increased overall acceptability. These results are in accordance with Turp and Serdaroglu (2008) demonstrated that replacing beef fat with olive oil and hazelnut oil improved the quality characteristics of fermented sausages.

CONCLUSION

Based on the above results, it can be concluded that chicken meat sausages added with 6% per cent flax seed oil (T3) had significantly (P<0.05) higher cooking yield, emulsion stability, water holding capacity, protein and fat than control and remaining formulations. Further, chicken meat sausages added with 6% per cent flax seed oil (T3) had lower SFA values and higher MUFA values, n-6 PUFA and n-3 PUFA values, n6 PUFA/n3 PUFA ratio and PUFA/SFA ratio and superior sensory scores than control and remaining formulations.

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