Journal of Pharmacognosy and Phytochemistry
Available online at www.phytojournal.com

E-ISSN: 2278-4136
P-ISSN: 2349-8234
www.phytojournal.com
JPP 2020; Sp 9(5): 676-682
Received: 10-09-2020
Accepted: 18-10-2020

Influence of incorporation of ground sesame seed as fat replacer on the functionality of spent broiler breeder hen chicken sausages

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Abstract
Spent broiler breeder hen meat was utilized for the development of functional chicken sausages fortified with ground sesame seed at three different levels as fat replacer in order to study the influence of addition of ground sesame seed on physico chemical, proximate, fatty acid composition and sensory evaluation of functional chicken sausages**.** Functional chicken sausages fortified with ground sesame seed at 10% level were found to have significantly (P<0.05) higher pH, cooking yield, emulsion stability, hardness, crude protein, crude fiber, total ash, PUFA/SFA ratio, mono and poly unsaturated fatty acids and significantly lower moisture, crude fat, cholesterol and saturated fatty acids when compared to the control and rest of the sesame seed fortified sausages but no significant difference was observed in sensory scores. The results suggested that replacement of animal fat with ground sesame seed is possible to develop healthy fatty acid profile and fiber enriched sausages.

Keywords: Chicken sausages, fat replacer, functionality, ground sesame seed, functional

Introduction
The disposal of spent broiler breeder hens is one of the main economical and environmental problems of the poultry industry as that meat is poorer in tenderness. Proper utilization of less expensive meat from spent broiler breeder hens to produce cheaper and economically viable nutritious value added meat products and make the poultry industry profitable. Processed meat products such as sausages contain high amount of fat. Animal fat often contains high levels of saturated fatty acids and cholesterol, which have been associated with obesity, hypertension, cardiovascular and coronary heart disease [8]. Therefore, reduction of animal fat in meat products and substitution of animal fat with vegetable oils and dietary fiber could result in healthier meat products [9]. Nutritionists generally recommend a change in composition of the fat associated with meat products by substituting MUFA for saturated fatty acids [43]. Fat reduction render meat products unacceptable due to a number of problems including those associated with texture and water binding properties [15]. Dietary fiber has been added to different meat products to counteract the problems caused by fat reduction [2, 36]. The incorporation of vegetable oilseeds in meat products may have a positive effect on consumer health as they are free of cholesterol and have a higher ratio of unsaturated to saturated fatty acids and dietary fiber [9, 27, 33] which is generally lacked in meat, further which has a therapeutic effect on some human diseases such as colon cancer, obesity, and cardiovascular diseases [35]. Therefore, addition of dietary fibers into processed meats has been considered a good strategy for enhancing the nutritional value of processed meats [38]. Sesame (*Sesamum indicm* L.) is one of the world's most important oil seed crops. The chemical composition of sesame seed contains 40-50% oil, 20-25% protein, 20-25% carbohydrate and 5-6% ash [17, 31].
Sesame paste is an ideal fat substitute for meat products, as it contains a high content of polyunsaturated fats. It is known to reduce cholesterol levels due to the high content of polyunsaturated fat in the oil, contains lignans, sesamine, sesamoline and sesamol which have antioxidant activity and is very stable against oxidation deterioration [1, 26, 44]. Sesame seeds were appreciated for their ability to add nutty flavour or garnish foods; they were primarily used for oil [14]. The present study was undertaken to develop functional improved low aft sausages from cheaply available spent broiler breeder hens by utilizing ground sesame seed as fat replacer.

Material and Method

Preparation of raw materials

Spent boiler breeder birds (females) of 72 weeks age were purchased from Chandragiri local market, transported and slaughtered at the Department of Livestock Products Technology, College of Veterinary Science, Tirupati. On the next day of the slaughter, spent broiler breeder hen chicken carcasses were deboned and meat was harvested. All subcutaneous fat and inter muscular fat was removed from the meat and used as the fat source. Sesame seeds were purchased from local super market and were separately cleaned thoroughly, dry roasted in a pan and made in to paste and were used to incorporate as partial replacer of animal fat in formulation of Functional sausages. The pastes were prepared freshly on the day of incorporation.

The spice ingredients purchased from local market were cleaned thoroughly and dried in a hot air oven at 50 ºC per 60 minutes. The ingredients were ground separately in a Blender (Model: Panasonic MX-AC 3005) and sieved through a fine mesh. The powders were mixed in suitable proportions to obtain the spice mix and were stored at room temperature in air tight container for further use.

Other non-meat ingredients like sugar, salt, garlic, onions, binder were purchased from local super market. Onions and garlic were peeled off and made a fine paste in the ratio of 3:1 with help of mixer grinder.

Meat and fat were separately subjected to thorough mincing a meat mincer (Continental CCE 89/189) through 6 mm diameter grinder plate to obtain a uniform mix and later through 4mm diameter plate. Minced meat was chopped with salt, sugar, phosphate, fat, ice flakes, refine wheat flour, spices and condiments for 8 min in a bowl chopper (Schadfen 58452 written). The treatment and control batters were stuffed into synthetic cellulose casings (SCC21) using horizontal sausage stuffer (SIRMAN – V15, Italy) and then linked, tied and cooked at 80^{o}C/40 min in moist heat. The batches of control and treatment cooked sausage samples, after cooling to ambient temperature were subjected to evaluate physic chemical, proximate and organoleptic parameters.

Functional chicken sausages were prepared by replacing the chicken fat with ground sesame seed in three different levels along with control as per the formulation given in Table.1. Control sausages were prepared with inclusion of the % 15 chicken fat with no GSS whereas T1 sausages were formulated with 10% fat + 5% GSS, T2 sausages were formulated with 7.5% fat + 7.5% GSS and T3 sausages were formulated with 5% + 10% GSS. Three treatments along with control were analyzed to select the optimum level of replacement of GSS in formulation of Functional sausages basing on the physico chemical, proximate, fatty acid profile, cholesterol and sensory evaluation.

Table 1: Formulations of low fat chicken sausages fortified with ground sesame seed (GSS) as fat replacer at different levels

Ingredient	Control	Low fat sausages incorporated with GSS		
		T1	T2	T3
Chicken Meat (%)	85	85	85	85
Chicken Fat (%)	15	10	7.5	5
Ground Sesame Seed (%)	0	5	7.5	10
Salt (%)	1.8	1.8	1.8	1.8
Sugar %	1	1	1	1
Polyphosphate (STPP) %	0.3	0.3	0.3	0.3
Ice %	10	10	10	10
Dry Spice mix %	2	2	2	2
Wet Condiment mix*	3	3	3	3
Binder (Maida)	3	3	3	3

* Onion: Garlic paste (3:1)

Analysis

Physico chemical parameters

The pH of the samples was determined by following the procedure of Jay [16]. Meat sample weighing 25 grams was blended with 100 ml of distilled water for one minute in a mechanical blender. From the total homogenate a 50 ml aliquot portion was immediately used for determination of pH using a digital pH (Systronics µ pH system 361) meter after standardizing the instrument with two standard buffers.

Percent cooking yield was estimated by recording the difference between the pre and post cooking weights of meat sausages and expressed in percentage.

Percent Emulsion stability of the sample was determined by the method followed by Blinga and Madaiah. [5]. Twenty five grams of emulsion was taken in a sealed polythene bag and cooked at 80 °C for 30 minutes in a water bath. Cookout was drained, cooked mass was cooled and weighed, and same was expressed as percent emulsion stability.

The hardness of the product was measured in terms of penetration value (penetration value × 10-1 mm) with the help of cone Penetrometer as described by Dixon and Parekh [10].

Proximate composition including the per cent moisture, crude protein, crude fat and crude fibre were estimated as per the procedures outlined by AOAC [3]. Cholesterol was estimated as per the method described by Wybenga *et al*., [39] as modified by Rajkumar [29]. Fatty acid composition was estimated by Folch *et al*., [13] and Lepage and Roy [22]. Sensory evaluation was done per the standardized formulations were oven cooked separately and subjected to sensory evaluation on a 9 point hedonic scale by semi-trained panelists.

Results and Discussion

Physico chemical parameters

Mean values of Physico chemical properties of sesame seed incorporated low fat chicken sausages are presented in Table 2. The pH of control sausages was significantly (P<0.05) lower than the treatments. T3 sausages replaced with 10% ground sesame seed (T3) had higher pH than rest of the treatments and control though it was not significant. The pH differed significantly (P<0.05) among Functional formulation and control. However, no significant difference was observed in pH values of T1 and T2 formulations. The low-fat chicken sausages incorporated with 10% ground sesame seed recorded higher values than the rest of the formulations. These findings are correlated with Castillo *et al*., [7] in hamburger meat and Sanjivikumar [34] in ground sesame seed incorporated turkey nuggets.

The mean percent cooking yield of low-fat chicken sausages was significantly ($P<0.05$) affected by addition of ground sesame seed. Cooking yield increased with increased addition of ground sesame seed. The formulation of low-fat chicken sausages added with ground sesame seed at 10% level recorded significantly higher cooking yield than rest of the formulations and control. This increase in cooking yield might be due to better moisture retention by ground sesame seed [44]. Findings of the present study are in agreement with Castillo *et al.*, in ham burger [7], Kang *et al.*, and Lee *et al.*, in pork sausages [19, 21].

The mean percent emulsion stability of low-fat chicken sausages was significantly ($P<0.05$) affected by addition of ground sesame seed. The emulsion stability increased significantly ($P<0.05$) in treated sausages as compared to that of control. Functional sausages replaced with 10% ground sesame seed (T3) had significantly ($P<0.05$) higher percent emulsion stability values than rest of treatments and control. This increase in emulsion stability might be due to better moisture retention and emulsifying property of ground sesame seed [25, 12]. This is in conformity with Zhuang *et al.*, [44] who reported that the addition of sesamol, which is a lipid-soluble polyphenol, provides a hygroscopic effect that reduces moisture loss from muscle fibers by maintaining the integrity of the fiber membrane and therefore increased the water retention capacity of pork sausages. Purnima Mahesh [28] reported better emulsion stability in curry with added sesame paste**.** Choi [9] reported that the addition of rice fiber in meat products improves emulsion stability. Marchetti [23] reported that low-lipid meat emulsions formulated with protein (milk protein concentrate and whey protein concentrate) showed greater stability than control, indicating improved stability and water retention capacity in the emulsion.

All the formulations of low-fat chicken sausages recorded significantly ($P<0.05$) lower penetration values (Higher penetration value corresponds to lower hardness of the sausages) compared to the control and significant difference was observed between three low-fat formulations. Mean penetration values of Functional formulations decreased with increased level of addition of ground sesame seed. Functional sausages replaced with 10% ground sesame seed (T3) had significantly ($P<0.05$) lower penetration values than rest of treatments and control. This increase in hardness of sesame seed fortified sausages might be due to reduced fat and moisture percent. The cooked batters added with pre-emulsified sesame oil replaced pork back-fat had higher hardness [19]. The substitution of lipid source affected the hardness of mortadella sausages [24]. Similar results reported in low-fat sausages added with hydrated oatmeal and tofu as texture modifying agents [40].

Table 2: Effect of partial replacement of chicken fat with ground sesame seed on physico- chemical properties of functional chicken sausages

Parameter	Control	T1	T2	T3
pH	6.23 ± 0.004^a	6.27 ± 0.003^b	6.28 ± 0.002^b	6.29 ± 0.003^c
% Cooking yield	87.95 ± 0.16^a	91.02 ± 0.21^b	93.63 ± 0.14^c	94.73 ± 0.19^d
% Emulsion stability	87.00 ± 0.22^a	89.06 ± 0.26^b	91.13 ± 0.26^c	91.94 ± 0.18^d
Hardness (mm)	26.05 ± 0.22^a	22.91 ± 0.05^b	22.46 ± 0.04^c	21.52 ± 0.09^d

Control - 15% Chicken fat (CF); T1 - 10% CF + 5% GSS; T2 - 7.5% CF + 7.5% GSS; T3 - 5% CF + 10% GSS.
Note: Mean values bearing at least one common superscript do not differ significantly.

Proximate composition

Mean values of proximate composition of ground sesame seed incorporated Functional chicken sausages were presented in Table 3. Effect of partial replacement of chicken fat with ground sesame seed on proximate composition of Functional chicken sausages is represented in Fig no.1. Proximate composition of low-fat chicken sausages was significantly ($P<0.05$) affected by addition of ground sesame seed. Control sausages recorded significantly higher percent moisture and lower percent crude fiber than the treatments. Moisture percent decreased ($P<0.05$) with addition of ground sesame seed in functional chicken sausages with T3 recorded lowest. Similar trend was reported by Castillo *et al.*, and Sanjivi kumar *et al.*, in hamburger meat and turkey nuggets respectively [7, 34]. Ground sesame seed addition significantly affected ($p<0.05$) the protein content of the sausages with the highest protein content determined in Functional sausages having 10% ground sesame seed than rest of treatments and control. Sesame paste increases protein content in the treatments which show statistically significant differences ($p<0.05$) in relation to control. This might be due to relatively high protein content of sesame seed (21.80%). Similar trend is reported by Sanjivi kumar *et al.*, in turkey nuggets [34] and Castillo *et al.*, in hamburger meat [7], whereas Sanjeewa *et al.*, [32] found moisture and protein content of sesame added fish nuggets was comparable with that of control.

Addition of ground sesame seed significantly decreases the fat percent in treated sausages than in control. Sausages replaced with 5% ground sesame seed (T1) had significantly ($P<0.05$) lowest percent crude fat than rest of treatments and control. This might be due to decrease in the added chicken fat level in treated sausages as well as due to dilution resulted from addition of ground sesame seed. These findings are correlated with Castillo *et al.*, [7] in ground sesame seed fortified than functional hamburger and Turhan *et al.*, Yilmaz in meat balls [37] and meat burgers [42] respectively. Functional sausages added with 10% ground sesame seed recorded (T3) significantly ($P<0.05$) higher percent total ash and crude fiber than rest of treatments and control. This might be attributed to the high total ash (5.3%) and fiber (16%) contents of sesame seed [11]. Presence of crude fiber in control sausages (0.68%) might be due to added ingredients like binders and seasonings. These findings are correlated with Castillo *et al.*, [7] in sesame paste added hamburger, Kumar *et al.*, in chicken nuggets formulated with green banana and soybean hulls flours [20].

Effect of partial replacement of chicken fat with ground sesame seed on cholesterol of Functional chicken sausages is represented in Chart No.10. The mean cholesterol values of low-fat chicken sausages was significantly ($P<0.05$) affected by addition of ground sesame seed. Significant difference ($P<0.05$) was observed between Functional treatments and control. Cholesterol content of Functional treatments was decreased with increased addition of ground sesame seed. This might be due to the replacement of chicken fat with sesame paste. Similar trend was reported by Castillo *et al.*, in sesame paste added hamburger [7]. Functional sausages replaced with 10% Ground sesame seed (T3) had significantly ($P<0.05$) lower cholesterol than rest of treatments and control. This is in agreement with Choi *et al.*, in hamburgers substituted with vegetable oils and rice bran fiber [9].

Table 3: Effect of partial replacement of chicken fat with ground sesame seed on proximate composition of functional chicken sausages

Parameter	Control	T1	T2	T3
% Moisture	67.25 ± 0.12 a	65.72 ± 0.16 b	64.82 ± 0.11 c	63.34 ± 0.11d
% Crude protein	18.52 ± 0.05 a	21.18 ± 0.17 b	21.56 ± 0.11 c	22.14 ± 0.09d
% Crude fat	10.65 ± 0.06 a	9.16 ± 0.07b	10.08 ± 0.02c	10.78 ± 0.06 d
% Total ash	1.53 ± 0.05 a	1.60 ± 0.007 b	1.99 ± 0.02 c	2.08 ± 0.01 c
% Crude fiber	0.68 ± 0.03 a	1.09 ± 0.0.1 b	1.34 ± 0.02 c	1.44 ± 0.02 d
Cholesterol (mg)	81.45 ± 0.08 a	65.88 ± 0.03 b	55.21 ± 0.03 c	40.44 ± 0.04 d

Control - 15% Chicken fat (CF); T1 - 10% CF + 5% GSS; T2 - 7.5% CF + 7.5% GSS; T3 - 5% CF + 10% GSS.
Note: Mean values bearing at least one common superscript do not differ significantly.

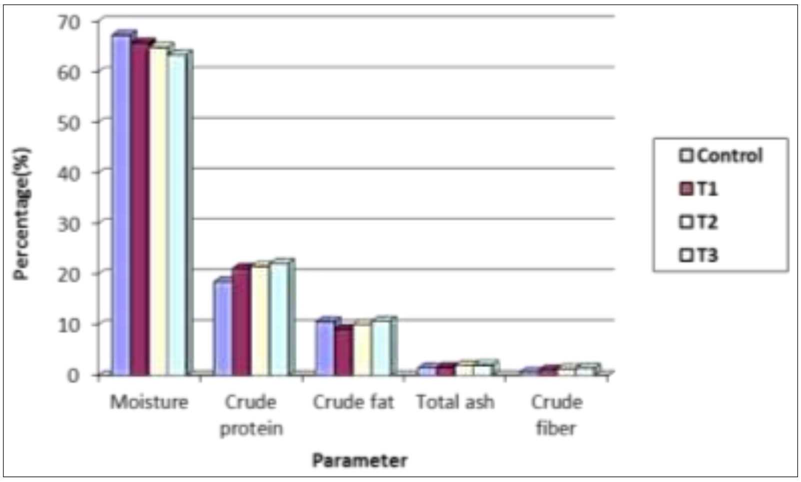

Fig 1: Effect of partial replacement of chicken fat with ground sesame seed on proximate composition of low fat chicken sausages

Fatty acid composition of functional chicken sausages

Mean values of Fatty acid composition of ground sesame seed incorporated Functional chicken sausages are presented in Table 4. Effect of partial replacement of chicken fat with ground sesame seed on fatty acid composition of Functional chicken sausages is represented in Fig No.3. The fatty acid composition of Functional chicken sausages was significantly (P<0.05) affected by addition of ground sesame seed. Ground sesame seed addition as animal fat replacer has changed (P<0.05) the fatty acid composition of sausages. Addition of sesame paste as partial fat replacer improved the lipid profile, reduced the saturated fatty acids and increased the unsaturated fatty acids and ratio of PUFA/SFA. These results are in accordance with Borchani *et al.*, [6]. Who reported that the sesame paste contains high monounsaturated to saturated fatty acid ratios? T3 sausages had significantly (P<0.05) higher percent of total poly unsaturated fatty acids (PUFA) and ratio of PUFA/SFA when compared to the other treatments and control. While highest (P<0.05) percent of mono unsaturated fatty acids (MUFA) was noticed in T2. This might be due to presence high unsaturated and lower saturated fatty acids in ground sesame seed. These findings are in agreement with Ali Asghar *et al.*, [1] and Castillo *et al.*, [7] in sesame added ham burger. Ground sesame seed addition decreased the saturated fatty acids like myristic acid, palmitic acid, stearic acid, behenic acid contents in functional sausages than control. Similarly, Yilmaz *et al.*, [41] recorded lower stearic (C18:0) and higher oleic (C18:1) fatty acid contents in reduced beef sausages than sausages of high beef content. Found significant reductions in myristic, palmitic, stearic and arachidonic fatty acids in salami with canola oil compared with those in control [4]. Linoleic acid and oleic acid percent of functional chicken sausages increased with increased level of addition of sesame seed and highest value was recorded in T3 sausages. These results are agreement with [1, 7, 11, 30].

Table 4: Effect of partial replacement of chicken fat with ground sesame seed on fatty acid composition of low fat chicken sausages

Parameter	Control	T1	T2	T3
Myristic acid (C14)	0.64 ± 0.004 a	0.56 ± 0.006 b	0.60 ± 0.006 c	0.45 ± 0.006 d
Palmitic acid (C16)	21.4 ± 0.06 a	19.40 ± 0.04 b	18.88 ± 0.02 c	16.80 ± 0.02 d
Stearic acid (C18)	5.09 ± 0.004 a	4.38 ± 0.03 b	4.74 ± 0.04 c	4.29 ± 0.03d
Behenic acid (C22)	0.42 ± 0.005 a	0.42 ± 0.005 a	0.30 ± 0.005 b	0.29 ± 0.01 b
Oleic acid (C18:1)	40.77 ± 0.06 a	40.82 ± 0.03 a	41.24 ± 0.02 b	42.39 ± 0.01 c
Palmitoleic acid (C16:1)	5.26 ± 0.014 a	4.13 ± 0.009 b	3.94 ± 0.02 c	2.76 ± 0.05 d
Linoleic acid (C18:2)	24.25 ± 0.015 a	28.79 ± 0.03 b	28.99 ± 0.02 c	32.15 ± 0.05 d
Linolenic acid (C18:3)	1.36 ± 0.006 a	1.27 ± 0.01 b	1.16 ± 0.01 c	0.78 ± 0.01 d
Arachidonic acid (C20:4)	0.16 ± 0.004 a	0.16 ± 0.01 a	0.11 ± 0.003 b	0.05 ± 0.003 c
Ecosapentaenoic acid (C20:5)	0.35 ± 0.006 a	---	---	---
Docosahexaenoic acid (C22:6)	0.13 ± 0.005 a	---	---	---
Others	0.12 ± 0.001 a	---	---	---
SFA	27.55 ± 0.07 a	22.98 ± 0.35 b	22.64 ± 0.37 b	21.04 ± 0.22 c
MUFA	46.03 ± 0.009 a	44.95 ± 0.04 b	45.18 ± 0.02 c	45.15 ± 0.01 d
PUFA	26.23 ± 0.01 a	30.22 ± 0.02 b	31.26 ± 0.01 c	32.98 ± 0.07 d
PUFA/SFA	0.95 ± 0.002 a	1.31 ± 0.01 a	1.38 ± 0.02 a	1.56 ± 0.01 a

Control - 15% Chicken fat (CF); T1 - 10% CF + 5% SSP; T2 - 7.5% CF + 7.5% SSP; T3 - 5% CF + 10% SSP.
Note: Mean values bearing at least one common superscript do not differ significant.

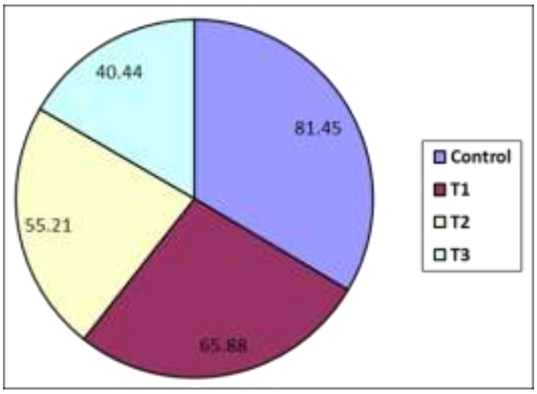

Fig 2: Effect of partial replacement of chicken fat with ground sesame seed on cholesterol content of low fat chicken sausages

Sensory evaluation

Mean values of sensory parameters of ground sesame seed incorporated Functional chicken sausages are presented in Table 5. The sensory parameters of low fat chicken sausages and control were non-significantly affected by ($P<0.05$) addition of sesame seed paste. However, T3 sausages scored uniformly higher scores for all sensory parameters than other treatments and control though it was not significant. Scores of all sensory parameters for three treatments of sausages were in the range of 7.47-7.79 (Good acceptability) which indicated that sesame seed paste addition did not affect the product quality as observed by the panel members. These results are in agreement with Kanchan Kumari [18] in chicken meat cutlets containing sesame paste and Sajivi Kumar *et al.,* [34] in sesame seed paste incorporated turkey nuggets.

Table 5: Effect of partial replacement of chicken fat with ground sesame seed on sensory parameters of Functional chicken sausages

Parameter	Control	T1	T2	T3
Appearance	7.40 ± 0.15 [a]	7.38 ± 0.12 [a]	7.37 ± 0.12 [a]	7.36 ± 0.13 [a]
Flavour	7.25 ± 0.13 [a]	7.36 ± 0.11 [a]	7.34 ± 0.11 [a]	7.33 ± 0.15 [a]
Juiciness	7.40 ± 0.13 [a]	7.38 ± 0.10[a]	7.37 ± 0.12 [a]	7.36 ± 0.14 [a]
Tenderness	7.33 ± 0.12 [a]	7.31 ± 0.13 [a]	7.30 ± 0.15 [a]	7.29 ± 0.15[a]
Overall acceptability	7.41 ± 0.15 [a]	7.40 ± 0.12 [a]	7.40 ± 0.11 [a]	7.38 ± 0.14 [a]

Control - 15% Chicken fat (CF); T1 - 10% CF + 5% GSS; T2 - 7.5% CF + 7.5% GSS; T3 - 5% CF + 10% GSS.
Note: Mean values bearing at least one common superscript do not differ significant.

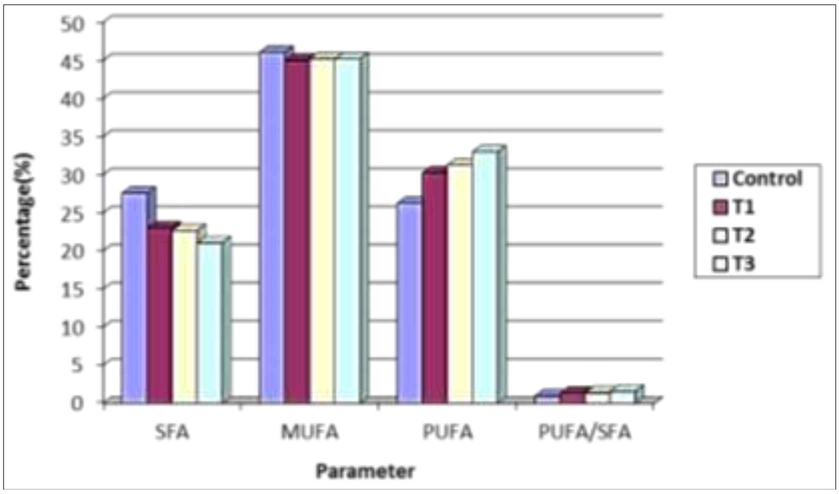

Fig 3: Effect of partial replacement of chicken fat with sesame seed paste on Fatty acid composition of low fat chicken sausages

Conclusion

Functional chicken sausages incorporated with 10% ground sesame seed (GSS) recorded significantly better scores in all physico chemical, proximate, fatty acid profile and sensory analysis. The functional chicken sausages had higher cooking yield and better Emulsion stability than control sausages. The functional chicken sausages recorded higher crude protein, crude fiber, total ash, PUFA/SFA ratio and poly unsaturated fatty acids and lower moisture, crude fat, cholesterol and saturated fatty acids compared to the control sausages. Even though control sausages recorded little higher sensory scores than functional sausages but found no significant difference between them. Thus concluding that ground sesame seed will be the better alternative to replace the chicken fat develop functional sausages with healthy fatty acid profile and rich fiber content without affecting the consumer acceptability.

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