International Journal of Bio-resource and Stress Management https://pphouse.org/ijbsm.php

Crossref

IJBSM August 2022, 13(8):887-898 Print ISSN 0976-3988 Online ISSN 0976-4038 Article AR3087

Research Article Natural Resource Management

DOI: HTTPS://DOI.ORG/10.23910/1.2022.3080

Study on the Keeping Quality of Functional Spent Broiler Breeder Hen Chicken Sausages at Refrigeration Temperature

J. Indumathi[1], M. Shashikumar[2], G. V. Bhaskarreddy[3], A. Jagadeesh Babu[4] and M. Gnanprakash[5]

[1]Dept. of Livestock Products Technology Sri Venkateswara Veterinary University, Tirupati, Andhra Pradesh (517 502), India
[2]Dept. of Livestock Products Technology, College of Veterinary Science, Hyderabad, Telangana (500 030), India
[3]Dept. of Livestock Products Technology, [4]Dept. of Veterinary Public Health, College of Veterinary Science, Tirupati, Andhra Pradesh (517 502), India
[5]Dept. of Animal Genetics and Breeding, Poultry Research Station, Rajendranagar, Hyderabad, Telangana (500 030), India

Open Access

Corresponding indumathijanagam@gmail.com

0000-0003-1507-4355

ABSTRACT

The present research was carried out in the Department of Livestock Products Technology, College of Veterinary Science, Tirupati, Andhra Pradesh, India during 2018–2019.The objective of this study was to assess the keeping quality of aerobically packed functional chicken sausages under refrigeration by using ground vegetable oilseeds on physico-chemical, proximate, microbiological and sensory properties of the product.Low-fat chicken sausages incorporated with three different ground vegetable oilseeds (poppy, sesame and peanut) at 10% level were developed and analyzed for their keeping quality along with high fat control under aerobic packaging conditions kept at chilling (4±1°C) temperature until spoilage. The mean values of FFA, TBARS, Tyrosine, standard, psychrophilic, yeast and moulds plate count for all for sausages were significantly ($p<0.05$) influenced by formulation and storage period and were increased significantly ($p<0.05$) throughout storage period irrespective of the formulations, while formulation did not show any significant influence on pH. Regardless of formulation, coli forms, lactobacillus and anaerobic counts could not be detected in all sausages throughout storage period. Sensory attributes showed a significantly ($p<0.05$) decreasing trend for both control as well as low-fat chicken sausages throughout storage period. Formulation had no significant influence on sensory parameters of chicken sausages throughout the storage period but were significantly ($p<0.05$) influenced by storage period. Study concluded that all three ground vegetable oil seed are effective in checking the lipid oxidation and microbial growth and preserving sensory quality during the storage period and among them sesame seed paste was proved to be a preferred preservative.

KEYWORDS: Chicken, functional, keeping quality, refrigeration, sausages, spent breeder

Citation* (VANCOUVER)*: Indumathi et al., Study on the Keeping Quality of Functional Spent Broiler Breeder Hen Chicken Sausages at Refrigeration Temperature. *International Journal of Bio-resource and Stress Management,* 2022; 13(8), 887-898. HTTPS://DOI.ORG/10.23910/1.2022.3080.

Data Availability Statement: Legal restrictions are imposed on the public sharing of raw data. However, authors have full right to transfer or share the data in raw form upon request subject to either meeting the conditions of the original consents and the original research study. Further, access of data needs to meet whether the user complies with the ethical and legal obligations as data controllers to allow for secondary use of the data outside of the original study.

Conflict of interests: The authors have declared that no conflict of interest exists.

RECEIVED on 07th May 2022 RECEIVED in revised form on 07th August 2022 ACCEPTED in final form on 20th August 2022 PUBLISHED on 29th August 2022

1. INTRODUCTION

In recent years the meat industry has evolved rapidly and new products have appeared, owing to the need to reduce costs and new consumer trends towards healthier products (Pintado et al., 2020). The fat content of meat formulations has been decreasing in order to develop meat products with an added nutritional value (Bennet et al., 2016,Yang et al., 2016). Because animal fat, often contains high levels of saturated fatty acids and cholesterol, which have been associated with obesity, hypertension, cardiovascular and coronary heart disease (Islamet al., 2019,Chernukhaet al., 2015). 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 (Choi et al., 2009). The main drawback of meat and its products is the absence of dietary fibre and the presence of saturated fat (Kausar et al., 2019). 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 (Choi et al., 2010, Pietrasik and Janz, 2010, Sanjeewa et al., 2010) dietary fiber. Dietary fiber has therapeutic effect on some human diseases such as colon cancer, obesity and cardiovascular diseases (Thebaudinet al., 1997). The incorporation of non-meat ingredients is not only necessary for nutrition but also for preventing nutrition-related disorders and for the mental-physical wellbeing of an individual (Kausar et al., 2019). Therefore, addition of dietary fibers into processed meats has been considered a good strategy for enhancing the nutritional value of processed meats (Verma et al., 2010). The fatty acid profile of meat and meat products can be changed by adding different lipids into meat products during processing (Arihara, 2006, Fruet et al., 2016). For this reason, nutritionists generally recommend a change in composition of the fat associated with meat products by substituting MUFA for saturated fatty acids (Zanardi et al., 2000). Several studies have been carried out on processed meat products with reduced fat and cholesterol content on replacing animal fat with carbohydrates, proteins, fibers and vegetable oil seeds (Ayo et al., 2007, Vural, 2003).

Poppy, sesame and pea nut seeds are rich inmono and polyunsaturated fat which helps in lowering blood cholesterol.Poppy seed (*Papaver somniferum*) rich in protein and linoleic acid which helps in lowering blood cholesterol. Poppy seeds contain poly-phenols like tannic acid, ellagitannin that act as antioxidantsproperties (Sathish kumar et al., 2016). Sesame (*Sesamum indicum* L.) is one of the important oilseed crops and its oil has excellent nutritional, medicinal,cosmetic and cooking qualities for which it is known as 'the queen of oils'(Ghosh etal., 2013). Sesame has the highest oil content of 46–64% (Sonia Shilpi et al., 2014). Sesame seeds contain lignans, sesamine, sesamoline and sesamol which have antioxidant activity and are very stable against oxidation deterioration (Peng et al., 2015, Zhuang et al., 2016). Groundnut (*Arachis hypogaea* L.) is a popularly grown leguminous oilseed crop and it isa preferred source of edible oil due to monounsaturated fats which is good for heart patients. Groundnut is a rich sourceof protein andresveratrol flavonoid which provides numerous health benefits (Ramanjaneyulu et al., 2021). Peanut seeds rich in polyphenols, antioxidants, vitamins, minerals and bioactive materials (Asen et al., 2021, Maria et al., 2008). The goal of this study was to assess the keeping quality of functional chicken sausages under aerobic packaging refrigeration by using some of the ground vegetable oilseeds like poppy, sesame and ground nut as partial animal fat substitutes basing on physico-chemical, proximate, microbiological and sensory properties of the product.

2. MATERIALS AND METHODS

The present research was carried out in the Department of Livestock Products Technology, College of Veterinary Science, Tirupati during months of November 2018 to February 2019. Spent boiler breeder birds (females) of 72 weeks age were purchased from Chandragiri local market and were utilized for the present study.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. Selected oilseeds like poppy, sesame and groundnut seeds were purchased from local super market. Three oilseeds 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 low-fat sausages. The pastes were prepared freshly on the day of incorporation.

Preliminary trails were conducted to select the optimum level of three vegetable oilseeds as partial fat replacers in the standardization of low-fat spent broiler breeder hen sausages. Both low-fat and control chicken sausages were prepared according to the formulations (Table 1) in to 4 batches that is, Control (15% chicken fat), T_1 (5% chicken fat+10% PSE), T_2 (5% chicken fat+10% SSP) and T_3 (5% chicken fat+10% GSP). The sausages were prepared, aerobically packed and were stored under refrigeration (4±1°C). Samples were analyzed regularly at 5 days interval for 20 days for evaluating their physico-chemical, microbial and organoleptic quality during storage period.

2.1. Analysis

The pH of the samples was determined by following the procedure of Jay (1964). FFA values were determined

Table 1: Formulations of low-fat chicken sausages fortified with optimum level of vegetable oil seed as fat replacer

Ingredient	Control	Low-fat sausages incorporated with vegetable oil seed as fat replacer		
		T_1	T_2	T_3
Chicken meat (%)	85	85	85	85
Chicken fat (%)	15	5	5	5
Poppy seed paste (%)	0	10	-	-
Sesame seed paste (%)	-	-	10	
Groundnut seed paste (%)	-	-	-	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)

based on the procedure of Koniecko (1979). TBARS values were determined based on the procedure of Witte et al, (1970). Tyrosine value of stored samples was determined based on the procedure of Strange et al. (1977). All the microbiological parameters of standard, psychrophilic, yeast and moulds, coliform, lactobacillus and anaerobic plate counts were determined according to the methods described by Anonymous (2001). Sensory evaluation ofchicken meat sausages was done by using 9 point hedonic scale by a semi-trained six member taste panel. The cost of production for the preparation of low-fat chicken sausages (kg^{-1}) was calculated by taking into account the cost of spent broiler breeder chicken meat, fat, vegetable oil seeds and other ingredients i.e. spice mix, condiments, binders and other processing charges. The data obtained in the present study was analyzed statistically by using methods outlined by Snedecor and Cochran (1980).

3. RESULTS AND DISCUSSION

3.1. Effect of formulation and storage period (4±1°C) on physico chemical quality of low-fat chicken sausages

3.1.1. pH

Mean pH values of sausages were affected by the formulation. Low-fat sausages differed significantly (p<0.05) from control sausages and highest pH values were observed in the control (Table 2). It might be due to greater fatty acid content and pH of vegetable oil seeds. The mean pH values of low-fat sausages were comparable with that of control up to 15 days of storage except sausages with SSP (B5) which differed significantly on 10th day of storage period. These findings are in accordance with Jo et al. (2018), Rindhe et al. (2009). Regardless of formulation, the mean pH values increased significantly (p<0.05) increased up to 15 days at refrigeration temperature at 4±1^0 C. This increase in mean pH up to 15 days of storage might be due to concomitant increase in bacterial load which release metabolites during their metabolism and cause deamination of proteins (Jay, 1996, Ahmed and Shrivasta, 2007). Low-fat chicken sausages revealed spoilage after 15 days of refrigeration storage (4±1°C). Similar trend was observed by Lima et al., (2021) in chicken sausages, Oliveira et al. (2021) in chicken sausages and Khatun et al. (2022) in chicken nuggets.

Table 2: Mean ± SE of pH values of low-fat chicken sausages as influenced formulation stored at refrigeration temperature (4±1°C)

Storage period (days)	Control sausages	Low-fat sausages with PSP	Low-fat sausages with SSP	Low-fat sausages with GSP
0	6.31± 0.004^{a1}	6.32± 0.005^{a1}	6.31± 0.009^{a1}	6.32± 0.005^{a1}
5	6.47± 0.001^{a2}	6.44± 0.016^{a2}	6.43± 0.011^{a2}	6.44± 0.009^{a2}
10	6.57± 0.013^{c3}	6.62± 0.006^{ad3}	6.59± 0.008^{cd3}	6.61± 0.015^{ad3}
15	6.69± 0.012^{a4}	6.68± 0.017^{a4}	6.67± 0.009^{a4}	6.70± 0.010^{a4}

Means bearing same numerical superscripts in each column and same alphabetical superscripts in each row do not differ significantly (p<0.05); PSP: Poppy seed paste; SSP: Sesame seed paste; GSP: Groundnut seed paste

3.1.2. Free fatty acid value (FFA)

Free fatty acid content can be considered as an indicator for lipid oxidation and flavour of the product. The mean FFA values were influenced by formulation. Low-fat formulation recorded significantly lower FFA values than control throughout the storage period (Table 3). This might be due to low lipolysis and lipolytic enzyme activity in low-fat sausages, leading to low production of free fatty acids. This low lipolytic activity of low-fat sausages might be due to total phenolics, flavonoids present in vegetable oilseeds (Shagufta et al., 2013, Francisco and Resurreccion, 2008). Among low-fat treatments, sausages with SSP were found to have lower FFA values. This

Table 3: Mean ± SE of FFA values of low-fat chicken sausages as influenced by formulation stored at refrigeration temperature (4±1°C)

Storage period (days)	Control sausages	Low-fat sausages with PSP	Low-fat sausages with SSP	Low-fat sausages with GSP
0	0.146± 0.002^{c1}	0.130± 0.001^{b1}	0.124± 0.001^{a1}	0.129± 0.001^{ab1}
5	0.192± 0.005^{f2}	0.154± 0.004^{d2}	0.142± 0.002^{ab2}	0.152± 0.004^{cd2}
10	0.246± 0.002^{e3}	0.218± 0.002^{d3}	0.177± 0.001^{b3}	0.185± 0.001^{b3}
15	0.269± 0.006^{f4}	0.247± 0.003^{e4}	0.213± 0.002^{c4}	0.225± 0.002^{d4}

Means bearing same numerical superscripts in each column and same alphabetical superscripts in each row do not differ significantly (p<0.05); PSP: Poppy seed paste; SSP: Sesame seed paste; GSP: Groundnut seed paste

Table 4: Mean±SE of TBARS values of low-fat chicken sausages as influenced by formulation stored at refrigeration temperature (4±1°C)

Storage period (days)	Control sausages	Low-fat sausages with PSP	Low-fat sausages with SSP	Low-fat sausages with GSP
0	0.219± 0.001^{b1}	0.214± 0.001^{ab1}	0.210± 0.001^{a1}	0.216± 0.003^{b1}
5	0.381± 0.002^{f2}	0.325± 0.001^{ed2}	0.311± 0.007^{d2}	0.323± 0.003^{e2}
10	0.655± 0.002^{e3}	0.538± 0.024^{d3}	0.427± 0.002^{c3}	0.521± 0.003^{d3}
15	0.830± 0.002^{g4}	0.733± 0.002^{f4}	0.697± 0.003^{d4}	0.725± 0.002^{e4}

Means bearing same numerical superscripts in each column and same alphabetical superscripts in each row do not differ significantly (p<0.05); PSP: Poppy seed paste; SSP: Sesame seed paste; GSP: Groundnut seed paste

might be due to the ability of sesame to act as hydrogen donors and they are the primary antioxidants that react with free radicals (Elleuch et al., 2012). These results are in conformity with Kumari (2013) in chicken meat cutlets. Control sausages recorded significantly (p<0.05) higher FFA values than any other treatments. This could be attributed to the high fat content in control and also this difference can be attributed to the higher oxygen permeability in aerobic packaging. These results are in agreement with Malav et al. (2015) in mutton patties. The mean free fatty acid values (% oleic acid) of all treatments were increased significantly (p<0.05) with advancement of storage period irrespective of the formulation. This might be due to progressive oxidation of lipids during storage. Similar increase in FFA content during storage has also been reported by Rokib et al. (2019) in chicken sausages, Khatun et al. (2022) in chicken nuggets and Maheshwara et al. (2017) in fish sausages.

3.1.3. Thio barbituric acid reactive substance value (TBARS)

Thio barbituric acid value is routinely used as an index of lipid oxidation in meat products in storage (Andres et al., 2006) and rancid flavours is initially detected in meat products between TBA values of 0.5 and 2.0 (Raharjo and Sofos, 1993). The mean TBARS values were influenced by formulation.Low-fat formulation recorded significantly (p<0.05) lower TBARS than control (Table 4). This might be attributed to anti-lipolytic and anti-oxidant effect of vegetable oil seeds (Shagufta et al., 2013).These results are in agreement with Karakaya et al. (2011). Low-fat sausages with SSP recorded lower TBARS mean values than other treatments and control. This might be due to superior antioxidant activity of the tetra-nor triterpenoids and phenolic compounds in sesame (Khan at al., 2019). Similar pattern was reported by Kumari (2013) in chicken meat cutlets.Control sausages recorded significantly (p<0.05) higher TBARS values than any other treatments. Similar findings were reported by Naveen Kumar (2015) in novel chicken sausages.

Low-fatchicken sausages were spoiled after 15 days of refrigeration storage (4±1°C). Regardless of formulation, the mean TBARS values of chicken sausages increased significantly (p<0.05) with increased storage period. This might be due to progressive oxidation of lipids during storage. Several authors have suggested that fluctuations in the TBARS values observed during the storage time are likely to be associated with increased concentrations of highly polar products resulting from the polymerization of secondary oxidation products. The TBARS values of all treatments during entire storage period were well below the minimum threshold values of 1–2 mg kg^{-1} (Green and Cumuze, 1982) and no off flavours were detected in all the treatments throughout the storage period probably due to anti oxidant property of vegetable oilseeds. These findings are in agreement with Oliveira et al. (2021) in chicken sausages, Khatun et al. (2022) in chicken nuggets and Naveen et al. (2016) in duck meat sausages.

3.1.4. Tyrosine value

Tyrosine values (mg/100 g) indicate protein break down during storage. Formulation influenced the mean tyrosine values of chicken sausages. Control sausages recorded significantly (p<0.05) higher tyrosine values than low-fat treatments (Table 5). Lower tyrosine values for treatments

Table 5: Mean±SE of tyrosine values of low-fat chicken sausages as influenced by formulation stored at refrigeration temperature (4±1°C)

Storage period (days)	Control sausages	Low-fat sausages with PSP	Low-fat sausages with SSP	Low-fat sausages with GSP
0	0.498± 0.005^{b1}	0.467± 0.007^{a1}	0.450± 0.007^{a1}	0.466± 0.006^{a1}
5	1.030± 0.02^{c2}	0.976± 0.017^{b2}	0.966± 0.01^{b2}	0.968± 0.02^{b2}
10	1.244± 0.022^{c3}	1.213± 0.02^{c3}	1.196± 0.03^{c3}	1.20± 0.01^{c3}
15	1.788± 0.02^{d4}	1.55± 0.01^{c4}	1.401± 0.01^{b4}	1.543± 0.01^{c4}

Means bearing same numerical superscripts in each column and same alphabetical superscripts in each row do not differ significantly (p<0.05); PSP: Poppy seed paste; SSP: Sesame seed paste; GSP: Groundnut seed paste

Table 6: Mean±SE of standard plate count values of low-fat chicken sausages as influenced by formulation stored at refrigeration temperature at (4±1°C)

Storage period (days)	Control sausages	Low-fat sausages with PSP	Low-fat sausages with SSP	Low-fat sausages with GSP
0	2.95± 0.004^{d1}	2.85± 0.01^{c1}	2.74± 0.010^{a1}	2.81± 0.01^{b1}
5	3.57± 0.05^{d2}	3.42± 0.04^{c2}	3.26± 0.085^{b2}	3.40± 0.05^{c2}
10	4.73± 0.01^{e3}	4.59± 0.020^{d3}	4.39± 0.092^{c3}	4.58± 0.01^{d3}
15	5.74± 0.01^{e4}	5.62± 0.016^{d4}	5.55± 0.015^{c4}	5.66± 0.01^{d4}

Means bearing same numerical superscripts in each column and same alphabetical superscripts in each row do not differ significantly (p<0.05); PSP: Poppy seed paste; SSP: Sesame seed paste; GSP: Groundnut seed paste

might be due to the effect of anti-microbial property of added vegetable oil seeds. Among low-fat treatments sausages with SSP recorded significantly lower tyrosine values than any other treatments, which might be due to superior anti-microbial properties (sesamol, sesamolin and sesamin) of sesame seed such as (Castillo et al., 2018). Control sausages had significantly (p<0.05) higher mean tyrosine values than any other treatments. These findings are agreement with Biswas et al. (2017) in comminuted chicken products, and Dushyanthan et al. (2001) in mutton.

The tyrosine values of all formulations significantly (p<0.05) affected by storage period and were increased significantly with increased storage period. The major cause for increase in the tyrosine values might be due to proteolysis brought either by microbial growth or chemical reaction (Kowaleet al., 2005). These results are in agreement with Triki et al., (2018) in meat and Biswas et al. (2017) in poultry and fish muscles.

3.2. Effect of formulation and storage period (4±1°C) on microbial quality of low fat chicken sausages

3.2.1. Standard plate count

The mean standard plate counts of chicken sausages were significantly influenced by formulation. Low-fat sausages differed from control (p<0.05) significantly (Table 6). Lower aerobic counts were reported by Kim et al. (2011) in low-fat pork sausages and Nayak et al. (2011) in low-fat nuggets than in control throughout the storage period. Among low-fat treatments, sausages with SSP recorded significantly (p<0.05) lower counts followed by GSP and PSP sausages. This indicates that all three vegetable oil seed pastes are effective in delay the microbial growth during the storage period and among them sesame seed was proved to be a preferred preservative ingredient. This might be attributed to superior antimicrobial effect of sesame seeds over groundnut and poppy seeds. Similar trend was reported by Bali et al. (2011) in chicken sausages. Control sausages had significantly (p<0.05) higher mean standard plate counts values than any other treatments. Similar observations were reported by Naveena et al. (2016) in chicken sausagesand Naveena et al. (2015) in emu meat.

Mean standard plate counts were influenced by storage period and increased significantly (p<0.05) as storage period advances irrespective of the formulation. This might be due to the permissive temperature and relative availability of moisture and nutrients for the growth of mesophilic bacteria and associated cross contamination (James et al., 2014). Similar trend was reported by several researches Maheshwara et al. (2017) in fish sausages Khatun et al. (2022) in chicken nuggets and Rokib et al. (2019) inchicken sausages.

3.2.2. Psychrophilic plate count

Mean psychrophilic counts were non significantly (p>0.05) influenced by the formulation. However, low-fat sausages incorporated with vegetable oil seeds recorded lower counts than control (Table 7). This might be due to antimicrobial properties of oilseeds and low-fat. Similar tendency was reported by Amaral et al. (2015) in low-fat pork sausages. Sausages with SSP recorded lower counts followed by low-fat sausages with GSP and PSP. This might be attributed to superior antimicrobial effect of sesame seeds over groundnut and poppy seeds.

Table 7: Mean±SE of psychrophilic counts of low-fat chicken sausages as influenced by formulation stored at refrigeration temperature (4±1°C)

Storage period (days)	Control sausages	Low-fat sausages with PSP	Low-fat sausages with SSP	Low-fat sausages with GSP
0	ND	ND	ND	ND
5	ND	ND	ND	ND
10	ND	ND	ND	ND
15	1.91± 0.03^{c}	1.72± 0.03^{b1}	1.56± 0.04^{b1}	1.65± 0.04^{b1}

Means bearing same numerical superscripts in each column and same alphabetical superscripts in each row do not differ significantly (p<0.05); PSP: Poppy seed paste; SSP: Sesame seed paste; GSP: Groundnut seed paste

Table 8: Mean±SE of yeast and mould counts of low chicken sausages as influenced by formulation stored at refrigeration temperature (4±1°C)

Storage period (days)	Control sausages	Low-fat sausages with PSP	Low-fat sausages with SSP	Low-fat sausages with GSP
0	ND	ND	ND	ND
5	ND	ND	ND	ND
10	ND	ND	ND	ND
15	1.25± 0.05^{a1}	1.17± 0.04^{a1}	1.13± 0.05^{a1}	1.14± 0.04^{a1}

Means bearing same numerical superscripts in each column and same alphabetical superscripts in each row do not differ significantly (p<0.05); PSP: Poppy seed paste; SSP: Sesame seed paste; GSP: Groundnut seed paste

Regardless of formulation, psychrophilic counts could not be detected up to 10 days of refrigerated storage in sausages due to more than a week of incubation period required by most of psychrophillic bacteria. The mean psychrophilic counts of sausages increased significantly (p<0.05) as refrigerated storage progressed from 10 to 30 days. This might be attributed to growth preference of psychrophilic organisms during storage at refrigeration temperature. Increase in psychrophilic count during storage of low-fat chevon rolls was reported by Yadav and Sharma (2004). The same pattern is observed by Dhamaveer et al. (2007) in chevon sausages.

3.2.3. Yeast and mould plate count

Mean yeast and mould counts were non significantly (p>0.05) influenced by the formulation. Low-fat sausages incorporated with vegetable oil seeds recorded lower counts than control (Table 8). This might be due to the anti-microbial and anti-mycotic properties of oilseeds. Low-fat sausages with SSP recorded lower counts followed by sausages with GSP and PSP. These results are correlated with Nayak et al. (2011) who noticed lower yeast and mould counts in low-fat nuggets than control throughout the storage period. Yu et al. (2010) stated that the antimicrobial effect of peat nut skin extract in ground beef was less potent. Devendra Kumar and Tanwar (2010) observed loweryeast and molds counts throughout the storage period in chicken nuggets containing ground mustard than in control. Regardless of formulation, the yeast and mould counts were not recorded in any of the sausages up to 10 days of refrigeration storage which may be attributed to longer incubation period of most yeast and mould. Verma et al. (2016) also recorded the yeast and mould counts only after 6th day of storage in chicken meat balls. The mean yeast and mouldcounts of sausages increased significantly (p<0.05) as refrigerated storage progressed from 15 to 30 days. Similar observations were reported by Rokib et al. (2019) in chicken sausagesand Khatun et al. (2022) in chicken nuggets.

3.2.4. Coli form plate count

Regardless of formulation, coli forms were not detected throughout the storage period in both control and low-fatsausages. This might be due to strict hygienic condition and correct method followed during preparing and processing of sausages. These results are in agreement with Zargar et al. (2014) in chicken meat balls.

3.2.5. Lacto bacillus plate count

Regardless of formulation, lactobacillus counts were not detected in both control and low-fatsausages throughout the refrigeration storage period. Similar trend was reported by Babji et al. (2000) in minced goat meat and Menegas et al. (2012) in fermented chicken sausages.

3.2.6. Anaerobic plate count

Anaerobic counts could not be detected in any of the sausages throughout storage period. These results are correlated with Kandeepan et al. (2010) buffalo meat keema and Malav et al. (2015) in vacuum packed mutton patties.

3.3. Effect of formulation, packaging and storage period (4±1°C) on sensory quality of low-fat chicken sausages

3.3.1. Appearance

Incorporation of vegetable oil seed pastes as fat replacer in sausages did not significantly affect mean appearance scores (Table 9). Similar trend was reported by Kumar et al. (2011) in green banana and soya hull flour added chicken sausages.

The mean appearance scores significantly (p<0.05) influenced by the storage period and were decreased as storage period progresses irrespective of the formulation. The decrease in appearance scores of sausages with

Table 9: Mean±SE of appearance scores of low-fat chicken sausages as influenced by formulation stored at refrigeration temperature (4±1°C)

Storage period (days)	Control sausages	Low-fat sausages with PSP	Low-fat sausages with SSP	Low-fat sausages with GSP
0	7.62±0.14[a1]	7.91±0.13[a1]	8.01±0.12[a1]	7.75±0.09[a1]
5	7.18±0.12[a2]	7.33±0.12[ab2]	7.56±0.12[ab2]	7.36±0.13[ab1]
10	6.40±0.10[a3]	6.43±0.11[a3]	6.47±0.12[a3]	6.45±0.13[a2]
15	5.91±0.15[a4]	5.93±0.17[a4]	6.19±0.15[a3]	6.09±0.18[a2]

Means bearing same numerical superscripts in each column and same alphabetical superscripts in each row do not differ significantly (p<0.05); PSP: Poppy seed paste; SSP: Sesame seed paste; GSP: Groundnut seed paste

advancement of storage period might be due to pigment and lipid oxidation (Bhat et al., 2011) and increased TBA values of samples (Tarladgis et al., 1960). Similar trend was reported by Oliveiraet al. (2021) in chicken sausages, Prathyusha et al. (2016) in chicken nuggets and Verma et al. (2015) in chevon patties.

3.3.2. Flavour

The flavour scores were unaffected by the addition of vegetable oil seed pastes. Low-fat chicken sausages with sesame seed paste scored significantly (p<0.05) higher flavour scores others (Table 10). This might be due to acceptable nutty flavour of sesame seeds. The overall mean flavour scores were significantly (p<0.05) influenced by the storage period and were decreased as storage period progresses irrespective of the formulation.The significant decrease in flavour scores of sausages with advancement of storage period could be attributed to the increased lipid oxidation, liberation of FFA and increased microbial load with the advancement of storage period (Bhat et al., 2011) and increased TBA values of samples (Tarladgiset al., 1960). Similar decrease in flavour scores during storage were reported by Rokib et al. (2019) inchicken sausages, Khatun et al. (2022) in chicken nuggets and Verma et al. (2016) in chicken meat ball with cabbage.

3.3.3. Juiciness

Formulation had no significant (p>0.05) affect on the mean juiciness scores of sausages. Low-fat sausages scored slightly higher than control which was non significant statistically (Table 11). High juiciness for low-fat sausages indicated that the fiber from vegetable oil seed paste retained the appropriate amount of moisture and fat to

Table 10 : Mean±SE of flavor scores of low-fat chicken sausages as influenced by formulation stored and refrigeration temperature (4±1°C)

Storage period (days)	Control sausages	Low-fat sausages with PSP	Low-fat sausages with SSP	Low-fat sausages with GSP
0	7.54±0.11[a1]	7.73±0.12[ab1]	7.94±0.12[b1]	7.74±0.09[ab1]
5	7.34±0.12[a1]	7.36±0.13[a1]	7.45±0.11[a2]	7.38±0.13[a1]
10	6.04±0.14[a2]	6.05±0.16[a2]	6.09±0.14[a3]	6.06±0.13[a2]
15	5.65±0.16[a3]	5.78±0.11[a2]	5.84±0.15[a3]	5.81±0.14[a2]

Means bearing same numerical superscripts in each column and same alphabetical superscripts in each row do not differ significantly (p<0.05); PSP: Poppy seed paste; SSP: Sesame seed paste; GSP: Groundnut seed paste

Table 11 : Mean ± SE of juiciness scores of low-fat chicken sausages as influenced by formulation stored at refrigeration temperature (4±1°C)

Storage period (days)	Control sausages	Low-fat sausages with PSP	Low-fat sausages with SSP	Low-fat sausages with GSP
0	7.52±0.11[a1]	7.75±0.12[a1]	7.86±0.13[a1]	7.66±0.10a1
5	7.11±0.19[a1]	7.23±0.15[a2]	7.25±0.15[a2]	7.27±0.18a1
10	6.18±0.16[a2]	6.23±0.12[a3]	6.55±0.15[abc3]	6.50±0.17[ab2]
15	5.65±0.14[a3]	5.79±0.13[a4]	6.04±0.20[ab4]	6.01±0.20[ab3]

Means bearing same numerical superscripts in each column and same alphabetical superscripts in each row do not differ significantly (p<0.05); PSP: Poppy seed paste; SSP: Sesame seed paste; GSP: Groundnut seed paste

assure a juicy product. Similar findings were reported by Choi et al. (2012), reported in reduced-fat pork patties and Selani et al. (2016) in low-fat beef burgers.

The mean juiciness scores were significantly (p<0.05) influenced by the storage period and decreased as storage period progresses irrespective of the formulation. Decrease in juiciness score might be attributed to the fact due to some loss of moisture from the product during storage. These findings are correlated with Rokib et al. (2019) inchicken sausages, Mir and Masoodi (2017) in meat balls and Khatun et al. (2022) in chicken nuggets.

3.3.4. Tenderness

The mean tenderness scores of sausages were not significantly (p>0.05) influenced by the formulation among low-fat treatments. Control sausages scored significantly lower values than low-fat treatments (Table 12). The present observations are in agreement with Naveen Kumar (2015) in novel chicken sausages. However, Peterssonetal. (2014) reported lower texture scores for Chinese style sausage and meat balls incorporated with oats.

The tenderness scores of sausages were significantly (P<0.05) influenced by the storage period and scores decreased significantly (p<0.05) as storage period progresses irrespective of the formulation. Decrease in tenderness might be due to loss of moisture and breakdown of fat and protein (Bhat et al., 2011) and subsequent reduction in pH and degradation of muscle fibre protein by the bacterial action (Jay, 1996), which resulted in decrease water-binding capacity during storage. Similar findings were reported by Oliveira et al. (2021) in chicken sausages and Naveen et al. (2016) in duck eat sausages.

Table 12: Mean ± SE of tenderness scores of low-fat chicken sausages as influenced by formulation stored at refrigeration temperature (4±1°C)

Storage period (days)	Control sausages	Low-fat sausages with PSP	Low-fat sausages with SSP	Low-fat sausages with GSP
0	7.90±0.12^{a1}	7.90±0.12^{a1}	7.95±0.12^{a1}	7.79±0.09^{a1}
5	7.40±0.13^{a2}	7.40±0.13^{a2}	7.46±0.13^{a2}	7.43±0.13^{a1}
10	6.51±0.15^{a3}	6.51±0.15^{a3}	6.66±0.17^{a3}	6.64±0.15^{a2}
15	6.08±0.19^{ab3}	6.08±0.19^{ab3}	6.18±0.20^{abc4}	6.00±0.13^{a3}

Means bearing same numerical superscripts in each column and same alphabetical superscripts in each row do not differ significantly (p<0.05); PSP: Poppy seed paste; SSP: Sesame seed paste; GSP: Groundnut seed paste

3.3.5. Overall acceptability

The mean overall acceptability scores of low-fat sausages and control sausages were significantly (p<0.05) influenced by the formulation (Table 13). Control sausages scored lower overall acceptability values than low-fat treatments. Andres et al. (2006) stated that low-fat chicken sausages had acceptable sensory scores with that of control. Although all the low-fat sausages had higher overall acceptability scores, they are comparable with the control which could be attributed to the higher flavour and textural scores. The overall acceptability scores of sausages were significantly (p<0.05) influenced by the storage period and decreased as storage period increased irrespective of formulation. Decrease in overall acceptability might be the synergistic effect of declining scores for all sensory parameters. Similar pattern was reported by Rokib et al. (2019) inchicken sausages, Khatun et al. (2022) in chicken nuggets and Yadav et al. (2016) dietary fiber enriched chicken sausages.

Table 13: Mean ± SE of overall acceptability scores of low-fat chicken sausages as influenced by formulation stored at refrigeration temperature (4±1°C)

Storage period (days)	Control sausages	Low-fat sausages with PSP	Low-fat sausages with SSP	Low-fat sausages with GSP
0	7.67±0.10^{ab1}	7.87±0.12^{b1}	7.79±0.14^{ab1}	7.90±0.08^{b1}
5	7.34±0.13^{a1}	7.36±0.12^{a2}	7.44±0.16^{a1}	7.39±0.15^{a2}
10	6.34±0.20^{a2}	6.49±0.14^{a3}	6.52±0.14^{abc2}	6.41±0.17^{ab3}
15	5.91±0.15^{a2}	5.98±0.12^{a4}	6.11±0.15^{a2}	6.01±0.15^{a3}

Means bearing same numerical superscripts in each column and same alphabetical superscripts in each row do not differ significantly (p<0.05); PSP: Poppy seed paste; SSP: Sesame seed paste; GSP: Groundnut seed paste

4. CONCLUSION

All the three ground vegetable oil seeds were found effective in checking the lipid oxidation, microbial growth and sensory quality during the storage period. Ground sesame seed was proved to be a preferred preservative and it had a definite advantage in preserving the sensory quality of chicken sausages over other two ground vegetable seeds. The low-fat chicken sausages along with high fat control were acceptable only up to 15 under refrigerated storage at 4±1°C.

5. REFERENCES

Ahmad, S., Srivastava, P.K., 2007. Quality and shelf-life evaluation of fermented sausages of buffalo meat with different levels of heart and fat. Meat Science 75(4), 603–609.

Amaral, D., Deborah, S., Alejandra, Cardelle-Cobas, Barbara, M.S., Nascimento, D., Maria, J., Monteiro., Marta, S., Madruga, Maria Manuela Pintado, E., 2015. Development of a low-fatlow-fat fresh pork sausagebased on chitosan with health claims: impact on the quality, functionality and shelf-life. Food and

Function 6(8), 2768–277.
Andres, S.C., Garcia, M.E., Zaritzky, N.E.,Caifano, A.N., 2006. Storage stability of low-fat chicken sausages. Journal of Food Engineering72 (4), 311–319.
Anonymous, 2001. Standard methods for the examination of water and waste water. American Public Health Association, 21th ed. APHAAWWA-WEF, Washington, DC, USA.
Arihara, K., 2006. Strategies for designing novel functional meat products. Meat Science 74(1), 219–229.
Asen, Nancy, D., Abdulhafiz, T., Badamasi, James, T., Gborigo, Rotimi, E., Aluko, Abraham, T.G., 2021. Comparative Evaluation of the Antioxidant Properties of Whole Peanut Flour, Defatted Peanut Protein Meal, and Peanut Protein Concentrate. Frontiers in Sustainable Food Systems 5(1), 1–11.
Ayo, J., Carballo, J., Serrano, J., Olmedilla-Alonso, B., Ruiz-Capillas, C., Jimenez-Colmenero, F., 2007. Effect of total replacement of pork backfat with walnut on nutritional profile of frankfurters. Meat Science 77(2), 173–181.
Babji, Y., Murthy, T.R.K., Anjaneyulu, A.S.R., 2000. Microbial and sensory quality changes in refrigerated minced goat meat stored under vacuum and in air. Small Ruminant Research 36(1), 75–84.
Bali, A., Das, S.K., Khan, A., Patra, D., Biswas, S., Bhattacharyya, D., 2011. A comparative study on the anti-oxidant and anti-microbial properties of garlic and coriander on chicken sausages. International Journal of Meat Science 1(2), 108–116.
Bennet, I.M.D., Guàrdia, C., Ibanez, J., Sola, J.A., Roura, E., 2016. Low intramuscular fat (but high in PUFA) content in cookedcured pork ham decreased Maillard reaction volatiles and pleasing aroma attributes. Food Chemistry 196(1), 76–82.
Bhat, Z.F., Pathak, V., Bukhari, S.A.A., Ahmad, S.R., Bhat, H., 2011. Quality changes in Chevon Harrisa (Meat based product) during refrigerated storage. International Journal of Meat Science 1(1) 52–61.
Bhat, Z.F., Pathak, V., Bhat, H.F., 2013. Effect of refrigerated storage on the quality characteristics of micro wave cooked chicken seekh kababs extended with different non meat proteins. Journal of Food Science and Technology 50(5), 926–933.
Bhattacharya, D., Sinhamahapatra, M., Biswas, S., 2013. Effects of packaging materials and methods on physical properties and food safety of duck sausages. International Journal of Development Research 3(5), 32–40.
Biswas, O., Talwar, N.A., Bhattacharya, D., Das, S.K., Chaudhary, S., 2017. Effect of refrigeration on quality andStability of fresh fish and poultry muscles. Indian Journal of Animal Health 56(1), 65-76.
Biswas, M.K., Debnath, C., Das, S.K., Pramanik, A.K., Biswas, S., Ganguly, S., Kumar, P., 2017. Studies on some comminuted meat products prepared from spent chicken during storage at refrigeration and frozen temperatures under aerobic packagingconditions. Indian Journal of Poultry Science 52(1), 104–113.
Castillo, P.M.M., Torres-Julio, E.P., Pérez-Rodríguez, D.P., 2018. Evaluation of the Effect of the Sesame Paste (*Sesamum indicum*) as Partial FatSubstitute in Hamburger Meat. International Journal of Engineering and Technology 10(1), 31–237.
Chernukha, I.M., Fedulova, L.V., Kotenkova, E.A., 2015. Meat by-product is a source of tissue-specific bioactive proteins and peptides against cardio-vascular diseases. Procedia Food Science 5(1), 50–53.
Choi, Y.S., Choi, J.H., Han, D.J., Kim, H.Y., Kim, H.W., Lee, M.A., Chung, H.J., Kim, C.J., 2012. Effects of Laminaria japonica on the physico-chemical and sensory characteristics of reduced-fat pork patties. Meat Science 91(1), 1–7.
Choi, S., Choi, J.H., Han, D.J., Kim, H.Y., Hyun-Wook, M.A.L., Jeong, K.J.Y., 2009. Characteristics of low-fatmeat emulsion systems with pork fat replaced by vegetable oils and rice bran fiber. Meat Science 82(2), 266–271.
Choi, Y.S., Choi, J.H., Han, D.J., Kim, H.Y., Lee, M.A., Kim, H.W., Lee, J.W., Chung, H.J., Kim, C.J., 2010. Optimization of replacing pork backfat with grape seed oil and rice bran fiber for reduced-fat meat emulsion systems. Meat Science 84(1), 212–218.
Devendra, K., Tanwar, V.K., 2010. Effects of incorporation of ground mustard on quality attributes of chicken nuggets. Journal of Food Science and Technology 48(6), 759–762.
Dharmaveer, S., Rajkumar, V., Mukesh, K.P., 2007. Quality and Shelf-Life of Smoked Chevon Sausages Packed under Vacuum and Stored at 4±1°C. American Journal of Food Technology 2(4) 238–247.
Dushyanthan, K., Shanmugam, A.M., Venkataramanujam, V., 2001. Influence of vacuumpackaging on certain chemical qualities of mutton. Indian Journal of Animal Sciences 71, 573–576.
Elleuch, M., Dorothea, B., Souhail, B., Christophe, B., Hamadi, A., 2012. Dietary fibre characteristics and antioxidantactivity of sesame seed coats (testae). International Journal of Food Properties15(1), 25–37.
Francisco Maria Leonora, D L., Resurreccion, A.V.A., 2008. Functional Components in Peanuts.Critical Reviews in Food Science and Nutrition 48(8), 715–746.

Fruet, A.P., Stefanello, F.S., Rosado, Junior, A.G., Souza, A.N., Tonetto, C.J., Nornberg, J.L., 2016. Whole grains in the finishing of culled ewes in pasture or feedlot: Performance, carcass characteristics and meat quality. Meat Science 113(14), 97–103.

Ghosh, A.K., Duary, B., Ghosh, D.C., 2013. Nutrient Management in Summer Sesame (*Sesamum indicum* L.) and its Residual Effect onBlack Gram (*Vigna mungo* L.). International Journal of Bio-resource and Stress Management 4(4), 541–546.

Gok, V., Obuz, E., Akkaya, L., 2008. Effects of packaging method and storage time on the chemical, microbiological and sensory properties of Turkish pastirma –A dry cured beef product. Meat Science 80(2), 335–344.

Greene, B.A., Cumuze, T.H., 1982. Relationship between TBA number and in experienced panellist's assessment of oxidized flavour in cooked beef. Journal of Food Science 47(1) 52–58.

Ilayabharathi, D., Sheriff, F.R., Raj Manohar, G., 2012. Shelf-life of spent chicken sausage andIts organoleptic qualities.Tamilnadu Journal of Veterinary and Animal Sciences8(2), 60–67.

Islam, M A., Amin, M N., Siddiqui, S A., Hossain, M P., Sultana, F., Kabir, M R., 2019. Trans fatty acids and lipid profile: a seriousrisk factor to cardiovascular disease, cancer and diabetes. Diabetes & Metabolic Syndrome: Clinical Research & Reviews13(1), 1643–1647.

James, H., John, D.K., Charles, M., 2014. Evaluation of microbial and sensory quality of raw and processed poultry sausages from native poultry in Uganda. International Journal of Science, Technology and Society 2(2), 18–27.

Jay, J.M., 1964. Beef microbial quality determined by extract release volume (ERV). Food Technology 18,1633.

Jay, J.M., 1996. Modern food microbiology (4th Ed.). NewDelhi: CBS Publishers and Distributors. Doi.org/10.1007/978-1-4615-7473-6.

Kandeepan, G., Anjaneyulu, A.S.R., Kondaiah, N., Mendiratta, S.K., 2010. Quality of buffalo meat keema at different storage temperature. African Journal of Food Science 4(6), 410–417.

Karakaya, M., Bayrak, E.,Ulusoy, K., 2011. Use of natural antioxidants in meat and meat products. Journal of Food Science and Engineering 1(1), 1–10.

Kausar, T., Hanan, E., Ayob, O., Praween, B., Azad, Z., 2019. A review on functional ingredients in red meat products. Bioinformation 15(5), 358–363.

Khan, U., Rathore, B.S., Syed, Z., 2019. Evaluation of Polyphenols, Flavonoids and antioxidant activityin different solvent extracts of Sesame (*Sesamum indicum* L.). Genotypes. International Journal of Seed Spices 9(2), 52–60.

Khatun, M.M., Hossain, M.A., Ali, M.S., Rahman M.M., Azad, M.A.K., Hashem, M.A., 2022. Formulation of value added chicken nuggetsUsing carrot and ginger as a source of dietary Fiber and natural antioxidant. SAARC Journal of Agriculture 20(1), 185-196. DOI: https://doi.org/10.3329/sja.v20i1.60611.

Kim, I.S., Jin, S.K., Mandal, P.K., Kang, S.N., 2011. Quality of low-fat pork sausages with tomato powder as colour and functional additive during refrigerated storage. Journal of Food Science and Technology 48(5), 591–597.

Koniecko, E.K., 1979. Handbook for meat chemists. Wayne, New Jersey, USA: Avery Publishing Group Inc (Ch. 6).68–69

Kowale, B.N., Kulkarni, V., Kesava Rao, V., 2005. Methods in meat science (Jaypee Brothers medical publishers (p) LTD, New Delhi) 97–98.

Kumar, V., Biswas, A.K., Chatli, M.K.,Sahoo, J., 2011. Effect of banana and soybean hull flours on vacuum-packaged chicken nuggets during refrigeration storage.International Journal Food Science and Technology 46(1), 122–129.

Kumari, K., 2013. Development of Chicken Meat Cutlets Incorporating Sesame Seeds.International Journal of Science and Research5(3), 458–461.

Lima, J.L., Assis Bianca, B.T., Lary, S.O., Mercia de S.G., Alida, J.S., Narciza M.O.A., Alberto, G.M., Taliana K.A.B., Marta, S.M., 2021. Effect of adding byproducts of chicken slaughter on the quality of sausage over storage. Poultry Science 100:101178 (https://doi.org/10.1016/j.psj.2021.101178).

Maheshwara, K.J., Jaya, N., Arun, B., Jagadish, T.D., 2017. Biochemical and shelf life study of quality of fish sausage in ambient and refrigerated storage. Biochemical and Cellular Archives 17(1), 265–270.

Malav, O.P., Sharma, B.D., Kumar, R.R., Talukder, S., Ahmed, S.R., Irshad, A., 2015. Antioxidant potential and qualitycharacteristics of functional mutton patties incorporated with cabbage powder. Nutrition and Food Science 45(4) 542–563.

Maria Francisco, M.L.D.L., Resurreccion, A.V.A., 2008. Functional components in peanuts. Critical Reviews in Food Science and Nutrition48(8), 715–746.

Menegas, L.Z., Pimentel, T.C., Garcia, S., Prudencio, S.H., 2012. Dry-fermented chicken sausage produced with inulin and corn oil: Physicochemical, microbiological and textural characteristics and acceptability during storage. Meat Science 93(3), 501–506.

Mir, S.A., Masoodi, FA., 2017. Effect of packaging on lipid oxidation, sensory and color attributes of the value added mutton meat balls during refrigeration. Journal of Nutritional Health and Food Engineering 7(3), 301–309.

Naveen Kumar, T.J., 2015. Quality studies of novel chicken sausage incorporated with paneer and oats. M.V.SC thesis submitted to Faculty of Veterinary and Animal Sciences, Kerala Veterinary and Animal Sciences University.

Naveen, Z., Naik. B.R., Subramanyam, B.V., Reddy, P.M., 2016. Studies on the quality of duck meat sausages during refrigeration.Springer Plus 5, 2061.

Naveena, B.M., Muthukumar, M., Kulkarni, V.V., Praveen Kumar, Y., Usha Rani, K., Kiran, M., 2015. Effect of Aging on the Physicochemical, Textural, Microbial and Proteome Changes In Emu (DromaiusNovaehollandiae) Meat Under Different Packaging Conditions. Journal of Food Processing and Preservation 39(6), 2497–2506.

Naveena, B.M., Panjab Khansole, S., Shashi Kumar, M., Krishnaiah, N., Vinayak, V., Kulkarni, Deepak, S.J., 2016. Effect of sous vide processing on physicochemical, ultrastructural, microbial and sensory changes invacuum packaged chicken sausages. Food Science and Technology International 23(1), 75–85.

Nayak, N.K., Pathak, V., Singh, V.P., Goswami, M., Bharti, S.K., 2011. Quality of carrageenan incorporated low-fat chicken nuggets during refrigerated storage at 40C. Livestock Research International 3(1), 7–13.

Oliveira, R.F.D., Favero, M.S., Mello, J.L.M.D., Ferrari, F.B., Cavalcanti, E.N.F., Souza, R.A.D., Pereira, M.R., Giampietro-Ganeco, A., Villegas-Cayllahua, E.A., Fidelis, H.D.A., 2021. Effects of storage on quality traits of sausages made withchicken breast meat affected bywooden breast. Animals 11, 513.

Peng, D., Bi, Y., Ren, X., Yang, G., Sun, S., Wang, X., 2015. Detection and quantification of adulteration of sesame oils with vegetable oils using gas chromatography and multivariate data analysis. Food Chemistry 188(1), 415–421.

Peterson, K., Godar, O., Eliasson, A.C., Tornberg, E., 2014. The effects of cereal additives in low-fat sausages and meat balls, Part 2: rye bran, oatbran and barley fibre. Meat Science 96(1), 503–508.

Pietrasik, Z., Janz, J.A.M., 2010. Utilization of pea flour, starch-rich and fiber-rich fractions in low-fat bologna. Food Research International 43(2), 602–608.

Pintado, T., Delgado-Pando, G., 2020. Towards more sustainable meat products: extenders as a way of reducing meat content. Foods 9(1), 1044.

Prathyusha, K., Naga Mallika, E., Eswara Rao, B., Srinivas Rao, T., 2016. Evaluation of edible polymer coatings enriched with green tea extraction quality of chicken nuggets.Veterinary World 9(7), 685–692.

Raharjo, S., Sofos, J.N., 1993. Methodology for measuring malonaldehydes a product of lipid peroxidation in muscle tissues: A Review, Meat Science 35(2), 145–169.

Rajesh, W.V., Manish, K.C., Marita, R., Eero, P., Per, E., 2015. Effect of various phyto-extracts on physico-chemical, colour and oxidative stability of pork frankfurters. Asian-Australasian Journal of Animal Sciences28(8), 1178–1186.

Ramanjaneyulu, A.V., Indudhar Reddy, K., Nagesh, K., Madhavi, A., Venkata Ramana, M., Srinivas, A., Suresh, G., 2021. Agro-economic feasibility and indices of castor+groundnut intercropping systemunder irrigated conditions during *rabi* season in Telangana. International Journal of Bio-resource and Stress Management 12(2), 074–081.

Rindhe, S.N., Zanjad, P.N., Suryawanshi, S.U., Ambadkar, R.K., Londhe, S.V., Kumar, S., Karle, S.D., 2009. Quality and storagestability of cooked chicken sausages incorporated with milkproteins. XVI Annual conference of Indian association for advancement of Veterinary Research (IAVVR), Mumbai, 43.

Rokib, M., Habib, M., Hashem, M.A., Ali, M.S., 2019. Value addition of low fat chicken sausage with rice and wheat flour. Bangladesh Journal of Animal Science 48 (2), 99-107.

Sanjeewa,W.G.T., Wanasundara, J.P.D., Shand, P.J., 2010. Physical, textural and sensory properties of low-fat pork bologna with added chickpea flour. Presented at: Institute of Food Technol annual meeting, from 28 June-1July, New Orleans, L.A. Poster, 134–12.

Sathish Kumar, T., Aishwarya, M., Archana, K., Divya, S., Seetha Lakshmi, S., 2016. Impact of Polyphenols on Cholesterol Esterase Inhibition – A Mini Review 3(10), 1058-1062.

Selani, M.M., Shirado, G.A.N., Margiotta, G.B., Saldana, E., Spada, F.P., Piedade, S.M.S, Contreras-Castillo, C.J., Canniatti-Brazaca, S.G., 2016. Effect of pineapple byproduct and canola oil as fat replacers on physicochemical and sensory quality of low-fat beef burger. Meat Science 112(1), 69–76.

Shagufta, I., Khan, K., Siddiqui, M.A., Siddiqi, R., Naz, S., 2013. Antioxidant potential of the extracts, fractions and oils derived from oilseeds. Antioxidants

2(4), 246–256.
Snedecor, G.W., Cochran, W.H., 1980. Statistical methods 13th edition Oxford and IBH publishing Co. Calcutta.
Sonia Shilpi, M., Nuruzzaman, M., Fahmina Akhter, M.N., Islam, M.N., Sutradher, G.N.C., 2014. Response of nitrogen and sulfur on the oil content of sesame and nutrient status of soil. International Journal of Bio-resource and Stress Management 5(1), 041–046.
Strange, E.D., Benedict, R.C., Smith, J.L., Swift, G.E., 1977. Evaluation of rapid tests for monitoring alteration in meat quality during storage. Journal of Food Protection 40(12), 843–847.
Tarladgis, B.G., Watts, B.M., Younthan, M.T., Dugan, L.R., 1960. A distribution method for the quantitative determination of malonaldehyde in rancid foods. Journal of American Oil Chemists Society 37(1), 44–48.
Thebaudin, J.Y., Lefebvre, A.C., Harrington, M., Bourgeois, C.M., 1997. Dietary fibres: Nutritional and technological interest. Trends in Food Science and Technology 8(2), 41–48.
Triki, M., Ana, M.H., Francisco, J.C., Claudia, R.C., 2018. Quality assessment of fresh meat from several species based on free amino acid and biogenic amine contents during chilled storage. Foods 7(9) 132. https://doi.org/10.3390/foods7090132.
Verma, A.K., Pathak, V., Singh,V.P., Umaraw, P., 2016 Storage study of chicken meatballs incorporatedwith green cabbage (Brassica olerecea) atrefrigeration temperature (4± 1°C) under aerobicpackaging. Journal of Applied AnimalResearch 44(1), 409–414.
Verma, A.K., Sharma, B.D., Banerjee, R., 2010. Effect of sodium chloride replacement and apple pulp inclusion on the physicochemical, textural and sensory properties of low-fat chicken nuggets. LWT - Food Science and Technology 43(1), 715–719.
Verma, A.K., Singh, V.P., Pathak, V., 2015. Effect of jackfruit supplement and ageing onthePhysico-chemical, texture and sensorycharacteristics of Chevon patties.Journal of Applied Animal Research 43(3), 247–255.
Vural, H., 2003. Effect of replacing beef fat and tail fat with interesterified plant oil on quality characteristics of Turkish semi-dry fermented sausages. European Food Research and Technology 217(2), 100– 103.
Witte, V.C., Krause, G.F., Bailey, M.E., 1970. A new extraction method for determining 2-thiobarbituric acid values of pork and beef during storage.
Yadav, S., Malik, A., Pathera, A., Islam, R., Sharma, D., 2016. Development of dietary fibre enriched chicken sausages by incorporating corn bran, dried apple pomace and dried tomato pomace. Nutrition and Food Science 46(1), 16–29.
Yadav, S., Sharma, D.P., 2004. Shelf life of low-fat chevon rolls developedusing whey protein concentrate, gaur gum and starch as fat replacers. Journal of Meat Science 2(1), 10–13.
Yang, H., Muhammad, A.K., Xiaobo, Y., Haibo, Z., Minyi, H., Xinglian, X., Guanghong, Z., 2016. Changes in protein structures to improve the rheology and texture of reduced-fat sausages using high pressureprocessing. Meat Science 12179–87.
Yu, J., Ahmedna, M., Goktepe, I., 2010. Potential of peanut skin phenolic extract as antioxidative andantibacterial agent in cooked and raw ground beef.International Journal of Food Science and Technology 45(7), 1337–1344.
Zanardi, E., Novelli, E., Ghiretti, G.P., Chizzolini, R., 2000. Oxidative stability of lipids and cholesterol in salame Milano, coppa and Parma ham: Dietary supplementation with vitamin E and oleic acid. Meat Science 55(2), 169–75.
Zargar, F.A., Kumar, S., Bhat, Z.F., Kumar, P., 2014. Effect of pumpkin on the quality characteristicsand storage quality of aerobically packagedchickensausages. SpringerPlus 3, 39.DOI: 10.1186/2193-1801-3-39.
Zhuang, X., Han, M., Kang, Z.L., Wang, K., Bai, Y., Xu, X.L., Zhou, G.H., 2016. Effects of the sugarcane dietary fiber and pre-emulsified sesame oil on low-fat meat batter physicochemical property, texture, and microstructure. Meat Science 113, 107–115.