The Pharma Innovation Journal 2023; 12(6): 461-466

www.ThePharmaJournal.com

The Pharma Innovation

ISSN (E): 2277-7695
ISSN (P): 2349-8242
NAAS Rating: 5.23
TPI 2023; 12(6): 461-466

www.thepharmajournal.com
Received: 01-03-2023
Accepted: 05-04-2023

Kiran Moyee Handique
Department of Livestock Products Technology, College of Veterinary Science, Khanapara, Guwahati, Assam, India

SK Laskar
Department of Livestock Products Technology, College of Veterinary Science, Khanapara, Guwahati, Assam, India

M Raquib
Department of Livestock Products Technology, College of Veterinary Science, Khanapara, Guwahati, Assam, India

S Choudhury
Department of Livestock Products Technology, College of Veterinary Science, Khanapara, Guwahati, Assam, India

S Upadhyay
Department of Livestock Products Technology, College of Veterinary Science, Khanapara, Guwahati, Assam, India

DP Bora
Department of Veterinary Microbiology, College of Veterinary Science, Khanapara, Guwahati, Assam, India

S Tamuly
Department of Veterinary Biochemistry, College of Veterinary Science, Khanapara, Guwahati, Assam, India

Corresponding Author:
SK Laskar
Department of Livestock Products Technology, College of Veterinary Science, Khanapara, Guwahati, Assam, India

Evaluation of certain physico-chemical and sensory qualities of duck meat sausages incorporated with foxtail millet flour (*Setaria italica*)

Kiran Moyee Handique, SK Laskar, M Raquib, S Choudhury, S Upadhyay, DP Bora and S Tamuly

Abstract
The present study aimed to develop and evaluate certain physicochemical and organoleptic qualities of duck meat sausages by incorporating three different levels of roasted foxtail millet flour (FTMF) (5%, 10% and 15%). The emulsion stability (ES) and the cooking yield (CY) increased significantly ($p<0.01$) with the addition of FTMF. The results for the pH of the products differed significantly ($p<0.01$) between the control and treated formulations during the entire storage period. The water activity (a_w) and the Thiobarbituric Acid Reactive Substance (TBARS) values decreased significantly ($p<0.01$) with the addition of FTMF. The results for the water holding capacity (WHC) showed the highest value for the sample with 15% FTMF. During storage at refrigeration temperature (4±1 °C), the pH, a_w and WHC showed a decreasing trend with the increase in storage period. However, the TBARS values increased significantly ($p<0.01$) up to 15 days of storage. The sensory scores for all attributes at a 5% level of FTMF incorporation were quite comparable with the control. Based on the findings, it was concluded that value-added, nutritionally balanced duck meat sausages could be made with 15% FTMF without adversely affecting their quality. It was acceptable for 15 days when stored under aerobic packaging and at refrigeration temperature (4±1 °C). However, among the treated products, duck meat sausages with a 5% level of foxtail millet flour were the best in terms of overall quality parameters.

Keywords: Foxtail millet flour, duck meat, sausages, physico chemical, sensory qualities

1. Introduction

Duck meat is a crucial food source in rural areas, particularly in South East Asia. In India, ducks are mainly concentrated in the Eastern, North-eastern and Southern states. Assam is one of the leading North-Eastern states regarding duck population and meat consumption. Although there is a greater demand for poultry meat than other animals, duck meat is consumed much lower than chicken meat. Additionally, duck meat has a stronger gamey flavour and more fat (13.8 percent) than chicken, so it may be less popular with consumers (Biswas *et al.*, 2019) [4]. However, the North-Eastern region of the nation has a high acceptance of duck meat.

Although meat contains a high amount of nutrients, it is highly susceptible to deterioration caused by microbes and enzymatic activity unless processed into a form that can be ingested or stored. The meat can be processed into sausages, burgers, and meatloaf to enhance the flavour, lengthen shelf life, and add value. By increasing the consumption of various value-added products, rural farmers can also raise ducks with good returns. Processed food items are becoming more popular due to the shifting socio-economic environment.

Health issues related to the fat content of foods have received a great deal of attention. Eating red meat and meat products is hampered by associated health issues such as colon cancer, cardiovascular disease and diabetes (Battaglia *et al.*, 2015) [2]. Also, many processed foods, including meat products, are deficient in fiber. Fiber-enriched meat products can help prevent coronary heart disease, diabetes, irritable bowel disease, obesity, and other diseases.

Various plant and animal sources are used extensively in ground meat systems as binders, fillers and extenders to extend the shelf life of meat products, improve quality and nutritional profile, and minimize cost of production. On the other hand, fiber can be effectively incorporated into processed meat products, for example, as binders, extenders, and fillers. They can significantly replace the harmful fat components of the meat product and thus increase acceptance by improving the nutritional profile, economic benefits and many physico-chemical parameters of the end products.

Foxtail millet (*Setaria italica*) is one of the most significant food crops of the semiarid tropics, which is free of gluten, low in fat (4%) and high in protein (11%) and dietary fiber (6.7%) (Talukder & Sharma, 2014) [30]. In Assam, foxtail millet is called "*Koni Dhan*" locally. As a diabetic food, foxtail millet was recognized for its value. Numerous macro and micronutrients are found in millets, including various phytochemicals such as phytosterols, phenolic acids, and lignans (Muthamilarasan *et al*., 2016) [18]. Using millet in meat products can balance the enormous demand and supply of affordable, wholesome, and healthful meat items (Talukdar & Sharma, 2015) [13]. Given the proper treatment with natural preservatives, the foxtail millet fortified meat sausage might be a novel product for consumers concerned about their health.

2. Materials and Methods

2.1Collection of raw materials

Hygienically slaughtered and de-feathered (Not Yet Dressed) carcasses of local ducks (*Pati* duck) of the same age group were purchased from poultry meat traders at the nearby market and immediately brought to the laboratory of the LPT Department of College of Veterinary Science, Khanapara. The carcasses were then properly dressed in the laboratory and preserved at -20 ºC temperature until use. Good quality foxtail millet was purchased from the supermarket. To prepare the foxtail millet flour, the purchased millet was cleaned and roasted well and then ground into fine flour with the help of a mechanical grinder.

2.2 Preparation of duck meat sausages

Deboning of the carcasses was done within three hours of slaughter. Then, liver, heart, gizzard, skin and visceral fat were harvested and packed in polyethylene bags before being put at a chilling temperature (4 °C). The required quantity of lean meat was packed separately in food-grade polyethylene bags and then stored at 4±1 °C temperature for 24 hours. The deboned duck meat, the heart, liver, and gizzard were chopped into small cubes after 24 hours of storage before being processed in a mechanical mincer using a 4 mm size pore plate. The previously melted visceral fat was separated with the help of a separating funnel, after which the recovered fat was stored for later use. The deboned meat was thoroughly mixed with the curing ingredients (Salt @ 1.75% and Sodium Nitrite @ 150 ppm) and then stored at 4 °C for another 24 hours to facilitate proper curing. The cured sausage mix was chopped in a bowl-chopper with the added fat, non-meat ingredients, spices and condiments and three different levels of foxtail millet flour, i.e. 5 percent(T_1), 10 percent(T_2) and 15 percent(T_3) in addition to the control (without foxtail millet flour). The four emulsions were prepared and then stuffed into the cellulose casings with the help of a mechanical stuffer. After stuffing, the sausages from each treatment group were cooked in a cooking vat at 85ºC for 45 minutes. After cooking, the hot sausages were immersed in ice-cold water to prevent further cooking. Then the sausages were removed from the water and the excess water was drained. The chilled sausages were peeled and packaged into sterilized polyethylene bags. They were then stored under refrigeration to evaluate the different qualitative traits during subsequent storage periods. Altogether, five batches of sausages were prepared and kept under refrigerated temperature (4±1 °C), and different qualitative traits were evaluated.

Table 1: Sausage mix formulation

Name of ingredients	Control	Treatment (%)		
		T_1	T_2	T_3
Lean Meat	70	65	60	55
Fat (skin + visceral organ)	15	15	15	15
Foxtail millet (*Koni dhan*) flour	0	5	10	15
Spices	1.5	1.5	1.5	1.5
Condiments	3	3	3	3
Egg white	3	3	3	3
Ice flakes	5	5	5	5
Salt	1.75	1.75	1.75	1.75
Sugar	0.75	0.75	0.75	0.75
Sodium Nitrite	150 ppm	150 ppm	150 ppm	150 ppm
Total	100	100	100	100

The emulsion stability of the samples was detected on the first day of the experiment using the technique of Mongale *et al*. (1985) [17]. The pH of the duck meat sausages was determined using a digital pH meter (Make: Eutech, Model: 510 Stirrer), and water activity (a_w) was determined by a water activity meter of Aqua Lab (Dewpoint water activity meter 4TE). The TBARS value was estimated following the method of Witte *et al*. (1970) [32]. The Water Holding Capacity of the duck meat sausages was determined by the method of Wardlaw *et al.* (1973) [31]. The organoleptic qualities of duck meat patties were determined by using a 9-point hedonic scale (Bratzler, 2000) [7] (9 = extremely desirable, 1=extremely undesirable).

3. Results and Discussion

3.1 Physico-Chemical Parameters

The emulsion stability (ES) of the duck meat sausages increased significantly ($p<0.05$) with the increasing level of FTMF. The improvement of the emulsion stability might be attributed to gelatinizing properties of the incorporated starch component on heating (Mishra *et al*., 2014) [16]. Many workers too observed similar findings by using different fillers/extenders, *viz*. finger millet (*Eleusine coracana*) flour on emu meat nuggets (Chatli *et al*., 2015) [8], finger millet flour (FMF) on chevon patties (Kumar *et al*., 2015) [12], oat flour on mutton nuggets (Reddy *et al*., 2017[a]) [22] and foxtail millet flour on chevon sausages (Reddy *et al*., 2017[b]) [23].

The cooking yield (CY) of the duck meat sausages showed a significantly ($p<0.05$) increasing trend with the increase in the level of FTMF. The improvement in cooking yield at the levels of FTMF described above could be due to the solubilization and dissociation of the foxtail millet proteins into subunits. The protein subunits of foxtail millet have unmasked the non-polar residues from the interior of the protein molecule, which may lead to increased water and fat absorption capacity in the stabilized sausage matrix (Reddy *et al*., 2017[b]) [23]. Reddy *et al.* (2017[b]) [23] also used foxtail millet flour (FTMF) on chevon sausages and found an increased cooking yield.

The pH of the duck meat sausages showed a significant ($p<0.01$) increase in the parameter along with the increasing level of the FTMF. This increase in pH might be due to the higher pH value of the FTMF (Nazni and Devi, 2016) [21] than lean duck meat. Storage studies revealed a significantly ($p<0.01$) decreasing trend in the pH of the duck meat sausages along with the increasing storage days at refrigeration temperature. The decrease in pH values with the advancement of the storage period might be due to the action of psychrophilic bacteria, which ferment the carbohydrate present in ingredients used in product formulation. A similar observation was noticed by Biswas *et al*. (2017) [5].

The a_w for duck meat sausages decreased significantly (p<0.01) in the treated products compared to the control. Such progressive decrease of a_w in the treated products might be attributed to increased levels of foxtail millet flour and firm binding of water with FTMF (Rindhe *et al*., 2018) [24]. Barros *et al*. (2018) also observed similar findings. Further, the a_w of duck meat sausages reduced markedly (p<0.01) from the 1st to the 15th day of storage. This might be due to the utilization of available water by the microbes for their growth and multiplication, as reported by Dharamveer *et al*. (2007) [9].

The TBARS value was found to be the highest in the control product compared to the treated products. Relatively lower TBARS values in treated products than in control might be due to the anti-oxidative property of FTMF, as it contains 47mg polyphenolics/100g and 3.34mg tocopherol/100 g (Suma and Urooj, 2012) [28]. The results are corroborated by the findings of Shinde *et al*. (2019) [27] and Gamit (2020) [10]. The TBARS value of both control and foxtail millet flour-treated duck meat sausages increased significantly (p<0.01) throughout the storage period indicating an increase in lipid oxidation. The increase in TBARS value during storage was due to increased lipid oxidation and the production of volatile metabolites (Joe *et al*., 2019) [11]. Results from several earlier workers, such as Nayeem *et al*. (2017) [20] and Shinde *et al*. (2019) [27], were found to be similar to the present study.

The highest WHC was observed in the T_3 (15 percent FTMF), while the lowest WHC was observed in the control. This might be due to the higher moisture absorption capacity of FTMF in meat emulsion. FTMF can absorb large quantities of water (water absorption 210%) via protein-water interactions without altering the product viscosity (Reddy *et al*., 2017b) [23]. These results are in agreement with Kumar *et al*. (2015) [12], Reddy *et al*. (2017a) [22] and Reddy *et al*. (2017b) [23]. With the increase in the storage days at refrigerated temperature, it was noticed that the WHC decreased significantly (p<0.01) in each treated as well as control product up to 15 days of storage. The decreasing trend might be due to the denaturation of myofibrillar protein, which lowers the hydration capacity of proteins and loosens up the microstructure of muscles, allowing more water to be entrained (Saikia *et al*., 2019) [25]. Nagamallika *et al*. (2006) [19] also reported a significant decrease in WHC in chicken patties during an increased storage period at refrigeration temperature.

Table 2: Emulsion stability & cooking yield of control and foxtail millet flour treated duck meat sausages

Parameters	Control	Incorporation of Foxtail millet flour		
		T_1 (5%)	T_2 (10%)	T_3 (15%)
Emulsion Stability (ml/g)	$2.4^a±0.28$	$2.16^a±0.29$	$1.28^b±0.14$	$0.88^b±0.14$
Cooking Yield (%)	$80.37^d±0.57$	$84.83^c±0.62$	$88.02^b±0.19$	$90.97^a±0.37$

n=5 Mean with superscript bearing different alphabet (small) row wise differ significantly (p<0.05)

Table 3: Physico-chemical qualities of control and foxtail millet flour treated duck meat sausages

Treatment	Days	WHC (ml/100g)	pH	a_w	TBA (mg malonaldehyde/kg)
C	1	$^A53.20^a±0.25$	$^A6.14^a±0.02$	$^A0.971^a±0.01$	$^A0.384^a±0.06$
	5	$^{AB}52.27^a±0.34$	$^B6.04^a±0.02$	$^B0.968^a±0.01$	$^B0.510^a±0.03$
	10	$^{BC}51.20^a±0.25$	$^{CD}5.85^a±0.01$	$^C0.957^a±0.01$	$^C0.709^a±0.03$
	15	$^C50.53^a±0.25$	$^D5.79^a±0.01$	$^D0.949^a±0.01$	$^D0.894^a±0.04$
T_1	1	$^A53.87^{ab}±0.25$	$^A6.17^{ab}±0.01$	$^A0.971^a±0.01$	$^A0.371^{ab}±0.06$
	5	$^{AB}52.67^a±0.42$	$^B6.08^{ab}±0.01$	$^B0.967^{bc}±0.01$	$^B0.498^{ab}±0.04$
	10	$^{BC}51.73^{ab}±0.27$	$^{CD}5.87^{ab}±0.02$	$^C0.957^a±0.01$	$^C0.688^{ab}±0.06$
	15	$^C50.93^{ab}±0.16$	$^D5.84^a±0.01$	$^D0.948^{bc}±0.01$	$^D0.878^{ab}±0.02$
T_2	1	$^A55.20^{bc}±0.44$	$^A6.20^{ab}±0.02$	$^A0.970^b±0.02$	$^A0.359^{bc}±0.08$
	5	$^{AB}54.40^{bc}±0.50$	$^B6.13^{bc}±0.02$	$^B0.967^c±0.01$	$^B0.483^{bc}±0.05$
	10	$^{BC}53.20^{bc}±0.57$	$^{CD}5.89^{ab}±0.01$	$^C0.957^a±0.06$	$^C0.672^{bc}±0.06$
	15	$^C52.27^{bc}±0.50$	$^D5.85^{ab}±0.02$	$^D0.948^c±0.01$	$^D0.858^{bc}±0.02$
T_3	1	$^A56.27^c±0.34$	$^A6.23^b±0.01$	$^A0.969^c±0.01$	$^A0.342^c±0.08$
	5	$^A55.60^c±0.34$	$^A6.17^c±0.02$	$^B0.966^d±0.01$	$^B0.466^c±0.03$
	10	$^{AB}54.67^c±0.47$	$^{BC}5.92^b±0.01$	$^C0.955^b±0.01$	$^C0.656^c±0.07$
	15	$^B53.60^c±0.62$	$^C5.87^b±0.01$	$^D0.947^d±0.01$	$^D0.840^c±0.04$

n=5 Mean with superscript bearing different alphabet (small) row wise differ significantly (p<0.01)
Mean with superscript bearing different alphabet (capital) column-wise differ significantly (p<0.01)

3.2 Sensory qualities
3.2.1 Colour
The perusal of sensory results revealed that colour scores for duck meat sausages declined significantly (p<0.01) along with the increasing level of FTMF. The colour scores following a decreasing trend might be due to the increased level of FTMF in the treated products, which reduced the dark colour of duck meat by diluting the meat pigment (Adzitey *et al*., 2021) [1]. The colour scores declined significantly and sharply until the 15th day of storage. A decrease in colour scores during refrigeration storage might be due to pigment and lipid oxidation resulting in non-enzymatic browning between lipid oxidation and amino acid. Biswas *et al.* (2011) [34], Reddy *et al*. (2017b) [23] and Gamit (2020) [10] too reported similar findings.

3.2.2 Flavour
The flavour scores for duck meat sausages declined significantly (p<0.01) along with the increasing levels of FTMF. This decrease in flavour scores might be due to the dilution of meaty flavour with the increase in the level of extender (Bhat *et al*., 2013, Malav *et al*., 2015) [3, 13]. This might also be due to the development of bitterness as a sequel of Maillard browning reactions with the increased level of foxtail millet flour in the treated products (Kumar *et al*., 2015) [12]. The results of the study corroborated well with the

findings of Mishra *et al*. (2014) [16] and Santhi and Kalaikannan (2014) [26]. The flavour scores declined significantly (p<0.01) and sharply up to the 15th day of storage. A decreased flavour score during storage might be due to increased malonaldehyde formation due to the oxidation of fat, which has a detrimental effect on the flavour and firmness of the product (Millar *et al*., 1980) [15] and also might be due to the oxidation of fat and microbial growth (Suresh *et al*., 2013) [29]. Similar findings were observed by Reddy *et al*. (2017^{b}) [23] and Gamit (2020) [10].

3.2.3 Juiciness

The juiciness scores for duck meat sausages declined significantly (p<0.01) along with the increasing levels of FTMF. The decrease in juiciness could be due to the decreased bulk density of the product at a higher level of extension, which was evident from a reduction in moisture content (Reddy *et al*., 2017^{b}) [23]. Gamit M. (2020) [10] also observed similar results in chicken meat cutlets incorporated with finger millet (*Eleusine coracana*) flour (5, 10 and 15 percent). In the present study, juiciness scores declined significantly (p<0.01) and sharply up to the 15th day of storage. A decrease in juiciness score during storage might be due to moisture loss. It might also be due to using low-density polyethylene packaging materials, which were permeable to water vapour (Biswas *et al*., 2011) [34].

3.2.4 Texture

The texture scores for duck meat sausages showed a significantly (p<0.01) decreasing trend along with the increasing levels of FTMF. Replacement of structural meat proteins by extender might be the reason for the decreasing trend of the texture scores (Verma *et al*., 2015) [8, 12]. The texture results obtained in the present study are similar to the work done by Mehta *et al*. (2013) [14] and Santhi and Kalaikannan (2014) [26]. A decrease in texture scores might be due to the release of moisture (Wu *et al*., 2000) and the depletion of fat during storage (Biswas *et al*., 2011) [34]. The present findings are in consonance with Reddy *et al*., 2017^{b}. They observed that the sensory scores for all sensory characteristics reduced gradually during storage.

3.2.5 Tenderness

Tenderness scores for duck meat sausages followed a significantly (p<0.01) decreasing trend along with the increasing levels of FTMF. This might be due to the increase in the hardness of the product due to the addition of the FTMF (Rindhe *et al*., 2018) [24]. The results obtained in the present study are similar to the work done by Mehta *et al*. (2013) [14], in which they mentioned that the addition of psyllium husk to patties generated lower scores for tenderness. A significantly (p<0.01) decreasing trend for tenderness scores was observed with the increase in the storage period. Loss of moisture from the product during prolonged storage might be the reason for the tenderness following a decreasing trend. The present findings are in consonance with Reddy *et al*. (2017^{b}) [23]. They observed that the sensory scores for all sensory characteristics reduced gradually during storage.

3.2.6 Overall Acceptability

The perusal of sensory results revealed that the overall acceptability scores for duck meat sausages declined significantly (p<0.01) along with the increasing levels of FTMF. Lower scores recorded for colour, flavour, juiciness, texture and tenderness qualities due to the addition of FTMF might be the reason for the decreased score for the overall acceptability of the product. Results of Mehta *et al*. (2013) [14], Mishra *et al*. (2014) [16] and Gamit (2020) [10] also revealed similar findings. The overall mean values for the overall acceptability of duck meat sausages for the different storage periods were found to decrease on the 1st, 5th, 10th and 15th day of storage, respectively. A decrease in colour scores during storage might be primarily due to the reduction of flavour and colour scores due to the development of some volatile flavour components as a consequence of the oxidation of fat, besides decreased moisture content, bacterial growth etc. The results obtained in the present study corroborated well with that of Biswas *et al*. (2011) [34] and Reddy *et al*. (2017^{b}) [23].

Table 4: Sensory quality parameters of control and foxtail millet flour treated duck meat sausages

Treatment	Days	Colour	Flavour	Juiciness	Texture	Tenderness	Overall Acceptability
C	1	$^{A}8.14^{a}\pm0.03$	$^{A}7.86^{a}\pm0.05$	$^{A}7.62^{a}\pm0.03$	$^{A}7.97^{a}\pm0.05$	$^{A}7.68^{a}\pm0.03$	$^{A}7.85^{a}\pm0.01$
	5	$^{AB}7.94^{a}\pm0.07$	$^{B}7.50^{a}\pm0.06$	$^{A}7.49^{a}\pm0.03$	$^{AB}7.69^{a}\pm0.03$	$^{BC}7.37^{a}\pm0.08$	$^{B}7.60^{a}\pm0.02$
	10	$^{BC}7.80^{a}\pm0.04$	$^{C}7.17^{a}\pm0.05$	$^{B}7.22^{a}\pm0.03$	$^{BC}7.54^{a}\pm0.03$	$^{CD}7.18^{a}\pm0.04$	$^{C}7.38^{a}\pm0.01$
	15	$^{C}7.57^{a}\pm0.05$	$^{D}6.80^{a}\pm0.03$	$^{C}6.94^{a}\pm0.03$	$^{C}7.28^{a}\pm0.09$	$^{D}7.05^{a}\pm0.03$	$^{D}7.13^{a}\pm0.02$
T_1	1	$^{A}7.80^{b}\pm0.07$	$^{A}7.77^{a}\pm0.07$	$^{A}7.51^{a}\pm0.03$	$^{A}7.80^{ab}\pm0.12$	$^{A}7.57^{a}\pm0.05$	$^{A}7.69^{b}\pm0.03$
	5	$^{A}7.74^{a}\pm0.08$	$^{B}7.38^{a}\pm0.08$	$^{B}7.25^{b}\pm0.03$	$^{AB}7.66^{a}\pm0.03$	$^{BC}7.25^{a}\pm0.10$	$^{B}7.46^{a}\pm0.02$
	10	$^{AB}7.65^{a}\pm0.07$	$^{C}7.10^{a}\pm0.07$	$^{CD}6.91^{b}\pm0.06$	$^{BC}7.40^{a}\pm0.07$	$^{C}7.11^{a}\pm0.10$	$^{C}7.23^{b}\pm0.02$
	15	$^{B}7.40^{a}\pm0.08$	$^{D}6.71^{ab}\pm0.08$	$^{D}6.74^{a}\pm0.03$	$^{C}7.23^{a}\pm0.03$	$^{D}6.80^{ab}\pm0.03$	$^{D}6.97^{b}\pm0.01$
T_2	1	$^{A}7.34^{cd}\pm0.05$	$^{A}7.31^{b}\pm0.08$	$^{A}7.00^{bc}\pm0.06$	$^{A}7.78^{ab}\pm0.07$	$^{A}7.29^{bc}\pm0.06$	$^{A}7.34^{c}\pm0.03$
	5	$^{B}6.77^{bc}\pm0.09$	$^{BC}6.88^{bc}\pm0.02$	$^{BC}6.66^{cd}\pm0.05$	$^{BC}7.31^{bc}\pm0.08$	$^{BC}6.91^{bc}\pm0.05$	$^{B}6.90^{bc}\pm0.03$
	10	$^{CD}6.34^{bc}\pm0.03$	$^{C}6.80^{b}\pm0.03$	$^{C}6.43^{c}\pm0.04$	$^{CD}7.08^{bc}\pm0.09$	$^{CD}6.77^{bc}\pm0.03$	$^{C}6.68^{c}\pm0.01$
	15	$^{D}6.17^{bc}\pm0.05$	$^{D}6.51^{bc}\pm0.05$	$^{D}6.11^{bc}\pm0.05$	$^{D}6.83^{bc}\pm0.05$	$^{D}6.54^{bc}\pm0.10$	$^{D}6.43^{cd}\pm0.05$
T_3	1	$^{A}7.14^{d}\pm0.14$	$^{A}6.94^{c}\pm0.09$	$^{A}6.77^{c}\pm0.07$	$^{A}7.65^{b}\pm0.11$	$^{A}7.02^{c}\pm0.07$	$^{A}7.10^{d}\pm0.07$
	5	$^{B}6.62^{c}\pm0.07$	$^{AB}6.77^{c}\pm0.06$	$^{A}6.57^{d}\pm0.10$	$^{BC}7.30^{c}\pm0.10$	$^{A}6.88^{c}\pm0.07$	$^{B}6.83^{c}\pm0.03$
	10	$^{CD}6.30^{c}\pm0.10$	$^{BC}6.54^{c}\pm0.07$	$^{B}6.17^{d}\pm0.08$	$^{CD}7.07^{c}\pm0.07$	$^{BC}6.60^{c}\pm0.05$	$^{C}6.53^{d}\pm0.04$
	15	$^{D}6.21^{c}\pm0.06$	$^{C}6.37^{c}\pm0.09$	$^{C}5.90^{c}\pm0.09$	$^{D}6.80^{c}\pm0.09$	$^{C}6.37^{c}\pm0.07$	$^{D}6.33^{d}\pm0.05$

n=5 Mean with superscript bearing different alphabet (small) row wise differ significantly (p<0.01) Mean with superscript bearing different alphabet (capital) column-wise differ significantly (p<0.01)

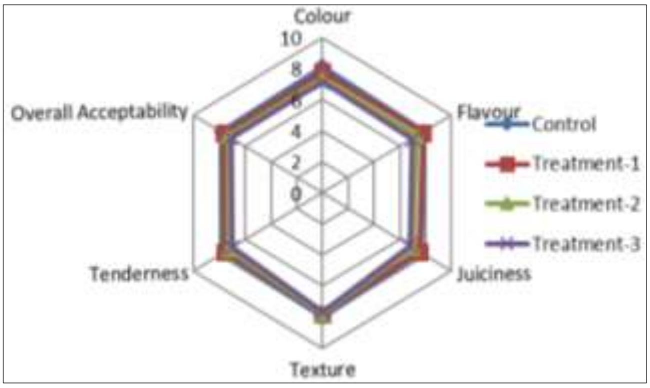

Fig 1: Graphical representation of Sensory quality parameters of control and foxtail millet flour treated duck meat sausages(1st day)

4. Conclusion

Based on the results of various parameters studied in this investigation, it may be concluded that duck meat sausages can be prepared satisfactorily by replacing lean meat and incorporating foxtail millet flour up to 15 percent without severe adverse effects on its physicochemical and sensory qualities and were acceptable for 15 days under aerobic packaging and refrigerated storage condition (4±1 ºC). However, based on the scores obtained for different quality parameters, the duck meat sausages with a 5 percent level of foxtail millet flour incorporation were the best among the treated products. Hence, based on the above results, the most favourable incorporation level of foxtail millet flour in duck meat sausages was 5 percent. However, further studies with more product formulations, larger samples with more extended storage periods, and improved packaging systems might be of immense value to draw a concrete conclusion and recommending the best-suited formulation for a commercial venture.

5. Acknowledgement

The authors are grateful to the All India Coordinated Research Project on Post Harvest Engineering Technology (ICAR), Khanapara center for providing the necessary infrastructure facility to carry out the research work.

6. References

1. Adzitey F, Yaro J, Korese J, Jeinie M, Huda N. The effect of raw pearl millet flour inclusion on the quality and formulation cost of beef sausages. Potravinarstvo Slovak Journal of Food Science. 2021;15:1039-1048.
2. Battaglia RE, Baumer B, Conrad B, Darioli R, Schmid A, Keller U. Health Risks Associated with Meat Consumption: A Review of Epidemiological Studies. International Journal of Vitamin Nutrition Research. 2015;85(1-2):70-8.
3. Bhat Z, Pathak V, Fayaz H. Effect of refrigerated storage on the quality characteristics of microwave cooked chicken seekh kababs extended with different non-meat proteins. Journal of Food Science and Technology. 2013;50(5): 926-933.
4. Biswas S, Banerjee R, Bhattacharyya D, Patra G, Das A, Das S. Technological investigation into duck meat and its products: A potential alternative to chicken. World's Poultry Science Journal. 2019;75(4):609-620.
5. Biswas Md, Debnath C, Das S, Pramanik AK, Biswas S, Ganguly S, *et al*. Studies on some comminuted meat products prepared from spent chicken during storage at refrigeration and frozen temperatures under aerobic packaging conditions. Indian Journal of Poultry Scienc. 2017;52:104-113.
6. Biswas S, Chakrabort A, Patra G, Dhargupta A. Quality and acceptability of duck Patties stored at ambient and refrigeration temperature. International Journal of Livestock Productions. 2017;1(1):1-6.
7. Bratzler LJ. Palatability factors and evaluation in science of meat products. Price, J. F. and Schoriewert, B. S. (Eds.), W. H. Freeman and Co. San Francisco; c2000.
8. Chatli M, Kumar P, Mehta N, Verma A, Kumar D. Malav O. Quality characteristics and storage stability of emu meat nuggets formulated with finger millet (Eleusine coracana) flour. Nutrition & Amp Food Science. 2015;45(5):740-752.
9. Dharmaveer S, Rajkumar V, Mukesh K. Quality and Shelf-Life of Smoked Chevon Sausages Packed under Vacuum and Stored at 4±1 °C. American Journal of Food Technology. 2007;2(4):238-247.
10. Gamit M. Quality Characteristics of Chicken Meat Cutlets Incorporated with Finger Millet (Eleusine coracana) Flour. Journal of Animal Research, 2020, 10(1).
11. Joe C, Lee JI, D. UA. Lipid oxidation, colour changes and volatiles production in irradiated pork sausage with different fat content and packaging during storage. Meat Science. 2019;51(4):355-361.
12. Kumar D, Chatli M, Mehta N, Verma A, Kumar P. Quality evaluation of chevon patties fortified with dietary fibre. Indian Journal of Small Ruminants. 2015;21(1):85.
13. Malav OP, Sharma BD, Talukdar S, Mendiratta SK, Kumar RR. Development of low-fat functional restructured chicken meat blocks extended with lentil flour. Indian Journal of Poultry Science. 2015;48(3):329-332.
14. Mehta N, Ahlawat SS, Sharma DP, Yadav S, Arora D. Development and quality evaluation of chicken patties incorporated with psyllium husk. Haryana Veterinarian. 2013;52(2):6-11.
15. Miller AJ, Ockerman SA, Palumbe SA. Effect of frozen storage on functionality of meat for processing. Journal of Food Science. 1980;50:531-534.
16. Mishra BP, Chauhan G, Mendiratta SK, Rath PK, Desai BA. Effect of Barnyard Millet Flour on the Quality Characteristics of Dehydrated Chicken Meat Rings. Indian Veterinary Journal. 2014;91(08):45-49.
17. Mongale CW, Carpenter JA, Reagan JO. The effects of soluble and insoluble components of beef skeletal muscle on the stability of meat batters. Journal of Food Quality. 1985;8:145.
18. Muthamilarasan M, Dhaka A, Yadav R, Prasad M. Exploration of millet models for developing nutrient rich graminaceous crops. Plant Science. 2016;242:89-97.
19. Nagamallika E, Reddy KP, Reddy PM. Effect of storage on physicochemical, microbiological and sensory quality of chicken patties. Indian Journal of Poultry Science. 2016;41(3):271-274.
20. Nayeem M, Chauhan K, Khan MA, Siddiqui M, Sidduqui H. Development and shelf life studies of buffalo meat sausages incorporated with foxtail millet (*Setaria italica*). International Journal of Chemical Studies. 2017;5(3):648-654.

21. Nazni P, Devi SR. Effect of Processing on the Characteristics Changes in Barnyard and Foxtail Millet. Journal of Food Processing Technology. 2016;7:566.
22. Reddy D, Maheswara RG, Vijaya B, Gupta, RSD, Vani S. Effect of oat flour on physico-chemical characteristics of mutton nuggets. International Journal of Science Environment and Technology. 2017;6(1):248-253.
23. Reddy G, Mallika E, Reddy B, Veena D, Naik A. Effect of foxtail millet flour on quality and storage stability of functional chevon sausages. Indian Journal of Small Ruminants. 2017;23(1):61.
24. Rindhe SN, Chatli MK, Wagh RV, Kumar P, Malav OP, Mehta N. Development and quality of fiber enriched functional spent hen nuggets incorporated with hydrated wheat bran. International Journal of Current Microbiology and Applied Science. 2018, 7(12).
25. Saikia K, Laskar SK, Hazarika M, Das A, Talukdar A, Nath R. Evaluation of Certain Physico-Chemical and Sensory Qualities of Duck Meat Patties Incorporated with Black Gram Flour. International Journal of Livestock Research, 2019, 9(5).
26. Santhi A, Kalaikannan D. The Effect of the Addition of Oat Flour in Low-Fat Chicken Nuggets. Journal of Nutrition & Amp. Food Science. 2014, 04(01).
27. Shinde P, Londhe SV, Choudhary C, Bhumre P, Nemade A. Assessment of Shelf Life of Japanese Quail meat Nuggets Using Finger Millet Flour (*Eleusine coracana*) during refrigerated storage. Chemical Science Review and Letters. 2019;8(29):83-90.
28. Suma P, Urooj A. Antioxidant activity of extracts from foxtail millet (*Setaria italica*). Journal of Food Science and Technology. 2012;49(4):500-504.
29. Suresh D, Mendiratta SK, Anjaneyulu ASR. Effect of calcium lactate on the quality and shelf life of restructured pork rolls. Journal of Meat Science. 2013;1:1-6.
30. Talukder S, Sharma BD. Scope of millet grains as an extender in meat products. Food Science Nutrition. 2014;55(6):735-739.
31. Wardlaw ER, McCaskill LM, Acton JC. Effect of post-mortem muscle changes on poultry meat loaf properties. Journal of Food Science. 1973;38:421.
32. Witte VG, Krause GF, Barley ME. A new extraction method for determining 2-thiobarbituric acid value for pork and beef during storage. Journal of Food Science. 1970;35:582-583.
33. Wu Y, Rhim JW, Welle CL, Hamouz F, Cuppett S, Schnepe M. Moisture loss and lipid oxidation for precooked beef patties stored in edible coatings and films. Journal of Food Science. 2000;65:300-304.
34. Biswas K, He J, Zhang Q, Wang G, Uher C, Dravid VP, Kanatzidis MG. Strained endotaxial nanostructures with high thermoelectric figure of merit. Nature chemistry. 2011 Feb;3(2):160-166.