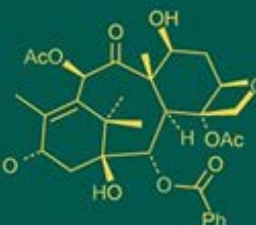
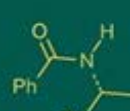
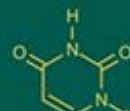
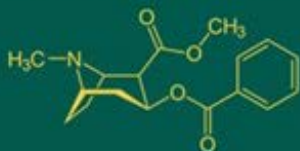


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Value addition of vanaraja spent hen meat using natural tenderizing agents.

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Abstract

The thigh portions from the carcass of vanaraja spent hens were subjected to different concentration of aqueous extract of ginger (2%, 4% and 6%) and compared with naive control without any treatment and positive control (0.2% papain). The treated thigh samples were kept for 24 hours at $4\pm 1^\circ\text{C}$ to allow ginger extract (G.E) act on them. After 24 hrs, the samples were divided into two groups. First group was analysed to evaluate the tenderizing effect of ginger extract. The results revealed that with increasing Ginger Extract level, there was an increase in pH, moisture content and water holding capacity; decrease in hydroxyproline content, collagen content and muscle fibre diameter and improvement in sensory parameters like appearance, colour and tenderness, thereby confirming the tenderness of spent hen meat. The other group of samples was cooked for 35 minutes in 1.5 % sodium chloride solution. Increased product yield, pH and moisture content; decreased shear force value and improved sensory scores in cooked samples was observed; more so in 6% ginger extract treatments. To evaluate the storage stability of raw and cooked samples treated with 6% Ginger Extract (selected as optimum), the samples packed in LDPE bags at $4\pm 1^\circ\text{C}$ were evaluated for microbiological and other quality parameters for 21 days. The microbiological quality (total plate counts, coliform counts and yeast and mold counts) was better in ginger treated samples on all days of storage and the microbial counts were within acceptable limits. The sensory quality was also acceptable throughout the storage period. It was therefore concluded that ginger extract has a tenderizing as well as antimicrobial action in vanaraja spent hen meat during its refrigerated storage.

Keywords: Ginger, microbiological, refrigerated storage, tenderizing, spent hen thigh, vanaraja

Introduction

The poultry industry in India has undergone a major shift in structure and operation during the last two decades, transforming from a backyard activity into a major industry with the presence of a large number of integrated players (Dublin, 2019)^[1]. This transformation has involved a sizeable investment in breeding, hatching, rearing and processing activities. Traditional backyard poultry keeping has been practiced since time immemorial. As per the 20th Livestock Census (2019), poultry population of India in 2019 was 851.81 million, of which backyard poultry contribute about 317.07 million (45.8% increase over previous census) and the total commercial poultry being 534.74 million (4.5% increase over previous census) (DAHD, 2021)^[2]. Mostly non-descript native birds are reared in backyard poultry sector because of their adaptability to local climate and feeding environment; but the main problem associated with them is low productivity (Kumar et al., 2019)^[3]. Directorate on Poultry Research, Hyderabad has thus developed improved chicken varieties which are tailor-made for better production and adaptability under different regions in rural and tribal backyard conditions. The various dual purpose varieties developed by Directorate of Poultry Research for rural poultry are Vanaraja, Gramapriya, Shrinidhi etc which have successfully been reared by farmers in several parts of the country.

Vanaraja is a superior stock, dual purpose coloured bird reared for both meat and eggs, contributing to a significant level to the rural economy of poultry farmers. Vanaraja was developed using a low performing coloured Cornish population as a male parent and a synthetic random breed as a female parent (Jha and Prasad, 2012)^[4]. In recent years, Shere-Kashmir University of Agricultural Sciences and Technology of Kashmir along with the Department of Animal Husbandry (Jammu and Kashmir) have tried to popularise the Vanaraja rearing among backyard poultry farmers. Typically, meat of Vanaraja males is consumed any time after they attain the body weight of 1.5 Kg or more and females are used for meat purpose after they complete their laying cycle. Upto 16 weeks of age,

Vanaraja chicken meat is tender enough to be consumed without any problem (Kumar *et al.*, 2019) [3]. However, as the age advances, the meat of Vanaraja becomes tougher, which adversely affects the quality of meat. Since, the female Vanaraja birds are slaughtered for meat only after they have completed their laying period, the meat so obtained is tougher and thus needs to be made tender before being consumed. This toughness of meat can be overcome by various tenderization methods using physical, chemical or enzymatic methods. Now-a-days, methods using natural ingredients are preferred by the health conscious consumer to avoid the ill effects associated with chemicals. Ginger (*Zingiber officinale*) is a typical flavoring agent widely used in the meat industry for its various benefits. Its proteolytic activity on collagen has been found to be many folds greater than most of the other methods. In addition, ginger has been shown to inhibit lipid oxidation, thus enhancing the keeping quality of meat (Tsai *et al.*, 2012) [5]. The present study was thus designed to evaluate the effect of Ginger (*Zingiber officinale*) Extract on the Quality and Storage Stability of Vanaraja Spent Hen Meat.

Material and Methods

Spent Vanaraja birds of more than 72 weeks of age were procured from "Poultry Seed Project for Vanaraja birds" operated by Division of Livestock Production and Management, F.V.Sc and A.H, SKUAST-Kashmir. Papain enzyme was procured from Himedia firm. For the preparation of Ginger Extract (GE), fresh ginger rhizome was peeled, sliced and blended with an equal quantity of chilled distilled water in a blender (Make: Ploytron PT 2100) for to 2 min. The homogenate was squeezed through 4 layers of muslin cloth and preserved for future use (Naveena and Mendiratta, 2010) [6]. The birds were slaughtered and dressed hygienically in the semiautomatic poultry processing plant at the Division of Livestock Products Technology, F.V.Sc and A.H, SKUAST-Kashmir. The thigh pieces were separated from the carcass, packed in LDPE bags and kept under refrigeration temperature till future use. Solutions of five treatments viz; naive control without any treatment (T₁); positive control containing 0.2% papain (T₂); 2% Ginger Extract (T₃); 4% Ginger Extract (T₄); and 6 % Ginger Extract (T₅) were prepared. About 100g of thigh meat samples were immersed in each treatment solution in a food grade plastic container and kept at 4±1 °C for 24 hours. The samples were divided in to two groups. One group of samples was evaluated for various parameters viz., pH, moisture content, water holding capacity, hydroxyproline content, collagen content, muscle fibre diameter and sensory evaluation. The other group of the samples was cooked for 35 minutes in 1.5% salt solution. The cooked samples were assessed for product yield, pH, moisture content, shear force value and sensory quality. The optimum level of GE (6%) was selected on the basis of the results obtained from analysis of above mentioned parameters. Each experiment was repeated thrice. To evaluate the storage stability of raw and cooked spent hen thigh meat of Vanaraja Layer Stock treated with optimum levels of tenderizing agents, the deboned uniform sized meat pieces of thigh muscles of Vanaraja layer spent hens were marinated using optimised levels of Ginger Extract (GE). The samples were divided into 3 groups viz; positive control treated with 0.2% papain (T₁); naive control without any treatment (T₂); 6 % GE treated samples (T₃). About 100 g of meat samples were immersed in GE solution in a food grade plastic container and kept at 4±1°C for 24 hours. Half of the marinated samples were

kept raw, packed in a low density polythene pouches and kept at the refrigerated temperature of 4±1 °C for a period of 21 days. Similarly, half of the marinated samples were cooked and aerobically packed in a low density polythene pouches and kept at the refrigerated temperate of 4±1 °C for a period of 21 days. Both the types of sample, were evaluated on 0th, 7th, 14th and 21th days for pH, moisture, sensory parameters and microbiological quality (total plate count, coliform count and yeast and mould count).

Analytical Procedures

The pH was determined following the method of Trout *et al.* (1992) [7] by using digital pH meter (Model CP 901, Century Instrument Ltd. India). The moisture content of samples was determined following the method of specified by AOAC (1995) [8]. The water holding capacity was determined following the method as specified by Wardlaw *et al.* (1973) [9]. Hydroxyproline content was quantitated calorimetrically using chloramine T method as described by Lee *et al.* (2005) [10] with slight modifications. The Collagen content was estimated by following the method specified by Koolmees and Bijker (1985) [11]. The procedure of Tuma *et al.* (1962) [12] was followed for determination of muscle fibre diameter.

Cooking yield was estimated by following formula

$$\text{Cooking yield (\%)} = \frac{\text{Weight of cooked samples}}{\text{Weight of uncooked samples}} \times 100$$

Textural quality of the sample was measured in terms of shear force value. It was estimated by using TA-XTi Texture analyser (STABLE MICROSYSTEMS, United Kingdom). The compression probe (HDP/ BSK- Blade set with knife) was applied to measure compression force required for sample breakage which indicates hardness. Total Plate Count, Coliform Count and Yeast and Mould Count as per the method described by APHA (1984) [13]. For cooked samples attributes viz., appearance, flavour, tenderness, juiciness, mouth coating and overall acceptability and for uncooked samples viz., appearance, tenderness and colour as per 8-point descriptive scale (Keeton, 1983) [14] and (Wierbicki, 1985) [15] were analyzed. The data generated was analyzed statistically following the method of Snedecor and Cochran (1968) [16] using SPSS version 20 software package.

Results and Discussion

In both raw and cooked samples, the pH increased significantly ($P \leq 0.05$) with Ginger Extract treatment (table-1). The higher pH values for GE treated samples compared to control might be due to higher pH (6.5) of ginger (Naveena *et al.*, 2004) [17]. This observation is in agreement with Reshi *et al.* (2017) [18], Naveena and Mendiratta (2010) [6] and Khanna and panda (2007) [19]. The moisture content of raw and cooked samples, being significantly ($P \leq 0.05$) higher for 6% GE treated samples compared to naive control. Increase in the moisture with increasing concentration of GE indicated improvement in hydrophilic properties by the GE and papain treatment. Moisture value in our observation is in agreement with Naveena and Mendiratta (2010) [6] and Naveena *et al.* (2004) [17] who also found increase in moisture content of Ginger Extract treated

spent hen and buffalo meat. The WHC of naive control was significantly ($P \leq 0.05$) lower than positive control and GE treated sample. The improved WHC in GE treated samples might be due to better moisture retention ability shown by the treated samples when compared with control. Naveena and Mendiratta (2010)^[6] found higher ($P \leq 0.05$) WHC in GE samples treated at the post-chill stage. Sinha and Panda (1985)^[20] have also reported increase in hydrophilic property of poultry meat due to papain treatment. The hydroxylproline content of positive control was significantly ($P \leq 0.05$) lower naive control and GE treated sample. The tenderization of muscle caused by Ginger Extract might have lead to the escape of hydroxyproline into the extract, thus resulting in lowered values in muscle itself. This observation is in agreement with Naveena and Mendiratta (2010)^[6] who has reported decreased hydroxyproline content in GE treated samples can be attributed to the tenderizing effect of ginger. The collagen content of naive control was significantly ($P \leq 0.05$) higher than positive control and GE treated sample. The decrease in collagen content with increasing concentration of GE and papain treated samples could be due to the proteolytic activity of ginger and papain on collagen, causing increased collagen solubility and thus decreased collagen content in the samples. This observation is in agreement with Naveena *et al.* (2004)^[17] found that the collagen solubility of meat after treatment with various proteolytic enzymes from plant extracts and commercial papain increased from 6.6 to 12.9%. Kim *et al.* (2013)^[21] found that

the total collagen solubility of beef treated with various levels of soy sauce increased from 2.5 to 40%. Muscle fibre diameter of naive control was significantly ($P \leq 0.05$) higher than positive control and 4% and 6% G.E treated samples. Reduction in muscle fibre diameter might be due to increased solubility and disintegration of myofilaments causing alteration in the muscle structure and possible stretching leading to reduction of muscle fibre diameter. Naveena *et al.* (2004)^[17] and Verma *et al.* (2018)^[22] have reported that the muscle fibre diameter values were slightly lower in all enzyme treated buffalo meat samples. Product yield values of 6% GE was significantly ($P \leq 0.05$) higher than naive control, 2% and 4% GE samples and non-significantly ($P > 0.05$) higher than positive control. Overall improvement in the yield in all GE treated samples indicated that treatment with GE had some beneficial effect on yield, probably because of better WHC and subsequent moisture retention. These findings are in agreement with Verma *et al.* (2018)^[22] and Naveena *et al.* (2004)^[17]. The shear force value decreased significantly ($P \leq 0.05$) with increasing ginger extract concentration, favorably attributing the role of GE as a tenderizer. Lee *et al.* (1986)^[23] found a linear decrease in shear force values with increasing amount of GE in beefsteaks. Similar observations were made by Naveena and Mendiratta (2010)^[6] in spent hen meat treated with different concentrations of ginger extract. Thompson *et al.* (1973)^[24] also reported a decrease in shear force values by ginger treatment in ovine *B. femoris* muscle.

Table 1: Quality parameters of spent thigh muscle treated with various levels of ginger extract (Mean $\pm$ S.E).

Parameters	Raw Vanaraja thigh				
	T ₁ (Naive control)	T ₂ (Positive control)	T ₃	T ₄	T ₅
pH	5.93 $\pm$ 0.21 ^a	6.09 $\pm$ 0.64 ^a	6.27 $\pm$ 0.94 ^{ab}	6.29 $\pm$ 0.1 ^b	6.29 $\pm$ 0.89 ^{ab}
Moisture content (%)	73.25 $\pm$ 1.04 ^a	74.63 $\pm$ 0.99 ^{ab}	73.75 $\pm$ 1.25 ^{ab}	74.76 $\pm$ 1.09 ^{ab}	77.10 $\pm$ 1.28 ^{ab}
WHC (%)	37.60 $\pm$ 0.64 ^a	41.79 $\pm$ 1.37 ^{bc}	40.41 $\pm$ 0.22 ^b	41.51 $\pm$ 0.19 ^{bc}	44.35 $\pm$ 0.17 ^c
Hydroxyproline content (% HP/100 g tissue)	0.13 $\pm$ 0.03 ^b	0.09 $\pm$ 0.01 ^a	0.11 $\pm$ 0.02 ^b	0.10 $\pm$ 0.04 ^b	0.10 $\pm$ 0.00 ^{ab}
Collagen Content (%)	4.87 $\pm$ 0.07 ^e	3.41 $\pm$ 0.07 ^a	4.26 $\pm$ 0.07 ^d	3.89 $\pm$ 0.07 ^c	3.65 $\pm$ 0.00 ^b
MFD (microns)	59.15 $\pm$ 3.19 ^b	42.15 $\pm$ 3.84 ^a	53.11 $\pm$ 3.69 ^b	43.03 $\pm$ 1.92 ^a	36.78 $\pm$ 1.67 ^a
Cooked Vanaraja thigh					
Product Yield (%)	70.36 $\pm$ 1.09 ^a	75.37 $\pm$ 2.37 ^c	71.17 $\pm$ 1.72 ^{ab}	73.17 $\pm$ 1.99 ^{ab}	75.47 $\pm$ 1.88 ^c
pH	6.22 $\pm$ 0.01 ^a	6.43 $\pm$ 0.02 ^c	6.29 $\pm$ 0.01 ^{ab}	6.34 $\pm$ 0.03 ^{ab}	6.42 $\pm$ 0.02 ^c
Moisture content (%)	59.11 $\pm$ 0.73 ^a	60.67 $\pm$ 0.27 ^{ab}	59.80 $\pm$ 0.92 ^a	61.04 $\pm$ 0.64 ^{ab}	62.23 $\pm$ 0.40 ^{ab}
Shear Force Value (N/cm ²)	22.57 $\pm$ 0.50 ^d	12.84 $\pm$ 0.94 ^a	19.41 $\pm$ 0.37 ^c	16.44 $\pm$ 0.84 ^b	13.92 $\pm$ 1.44 ^a

Row-wise group means with different superscript differ significantly ($P \leq 0.05$)

For product yield, N = 6 and for other parameters, N=6

Sensory Parameters

The results of different sensory parameters pertaining to raw and cooked samples are depicted in Table 2. The results revealed that the ginger extract treatment has led to improvement in all the sensory attributes including the overall acceptability in raw as well as cooked GE treated samples when compared to non-treated samples. Improvement of appearance, flavour, tenderness, juiciness and overall acceptability of G.E treated samples in our experiment were also reported by

Abdeldaiem *et al.* (2013)^[25]. Verma *et al.* (2018)^[22] observed that there was significant ($P \leq 0.01$) improvement in flavor, juiciness, tenderness and overall acceptability scores of all treated samples compared to control. Significant improvement in tenderness and overall acceptability scores of spent layer hens treated with cucumis powder was reported by Kumar and Berwal (1998)^[26]. Significant improvement of tenderness scores of papain treated samples were also reported by Gerelt *et al.* (2000)^[27].

Table 2: Sensory attributes of spent thigh muscle treated with various levels of ginger extract (Mean $\pm$ S.E)

Sensory attributes	Raw Vanaraja thigh				
	T ₁ (Naive control)	T ₂ (Positive control)	T ₃	T ₄	T ₅
Appearance	6.93 $\pm$ 0.18 ^{ab}	5.86 $\pm$ 0.29 ^a	6.66 $\pm$ 0.12 ^{ab}	6.80 $\pm$ 0.14 ^{ab}	7.00 $\pm$ 0.13 ^{ab}
Colour	6.00 $\pm$ 0.16 ^a	7.13 $\pm$ 0.09 ^{ab}	6.20 $\pm$ 0.17 ^a	6.53 $\pm$ 0.25 ^a	7.13 $\pm$ 0.21 ^{ab}
Tenderness	6.20 $\pm$ 0.15 ^a	6.73 $\pm$ 0.32 ^{ab}	6.46 $\pm$ 0.19 ^{ab}	6.60 $\pm$ 0.19 ^{ab}	6.66 $\pm$ 0.15 ^{ab}
Cooked Vanaraja thigh					
Appearance	6.77 $\pm$ 0.15	6.72 $\pm$ 0.13	6.94 $\pm$ 0.12	6.88 $\pm$ 0.07	6.94 $\pm$ 0.09
Flavour	5.88 $\pm$ 0.36 ^a	6.11 $\pm$ 0.25 ^{ab}	6.44 $\pm$ 0.23 ^{abc}	6.83 $\pm$ 0.18 ^{bc}	6.94 $\pm$ 0.15 ^c
Tenderness	5.44 $\pm$ 0.33 ^a	6.61 $\pm$ 0.31 ^{ab}	6.11 $\pm$ 0.30 ^{ab}	6.27 $\pm$ 0.31 ^{ab}	6.22 $\pm$ 0.30 ^{ab}
Juiciness	5.72 $\pm$ 0.25 ^a	6.00 $\pm$ 0.22 ^a	5.94 $\pm$ 0.27 ^a	6.00 $\pm$ 0.30 ^a	6.38 $\pm$ 0.24 ^{ab}
Overall acceptability	5.66 $\pm$ 0.26 ^a	6.62 $\pm$ 0.25 ^{ab}	6.27 $\pm$ 0.22 ^{ab}	6.55 $\pm$ 0.30 ^{ab}	6.61 $\pm$ 0.24 ^{ab}

Row-wise group means with different superscript differ significantly ($P \leq 0.05$)

8-point descriptive scale (8 = extremely desirable, 1 = extremely undesirable)

N = 21

Storage studies

The results of storage studies pertaining to raw and cooked samples are depicted in Table 3, and 5.

In GE treated samples, the pH of both raw and cooked samples was significantly ($P \leq 0.05$) higher than naive control. During storage, an increase in pH was observed in all the treatments including controls and the increase was significantly ($P \leq 0.05$) for all days of storage. Increase in pH of products during storage could be due to production of basic amines from protein breakdown by micro organisms. Different authors (Sunki, 1978; Nath, 1992; Bhat and Kumar 2014; Naveena *et al.* 2011) [28, 29,

30, 31] have also reported significant increase in pH of meat and meat products during refrigeration storage. Moisture value of raw and cooked GE treated samples was significantly ($P \leq 0.05$) higher than positive control and naive control. During storage, decrease in moisture content was observed. Decrease in the moisture with advancement in storage period might be due to moisture loss from treated samples and control during storage. Naveena *et al.* (2011) [31] and Muthulakshmi *et al.* (2018) [32] have reported that the moisture content was higher ($p \leq 0.05$) for the G.E treated sample compared to the control.

Table 3: Effect of storage period on pH and Moisture value of both raw and cooked Vanaraja thigh during refrigerated storage (4 $\pm$ 1°C)

Treatments	Storage period (days)			
	0	7	14	21
Raw vanaraja thigh				
pH				
NC (T ₁)	6.35 $\pm$ 0.01 ^{aA}	6.40 $\pm$ 0.00 ^{aB}	6.41 $\pm$ 0.01 ^{aB}	6.46 $\pm$ 0.01 ^{aC}
PC (T ₂)	6.38 $\pm$ 0.01 ^{abA}	6.42 $\pm$ 0.02 ^{abB}	6.45 $\pm$ 0.01 ^{abB}	6.51 $\pm$ 0.02 ^{abC}
GE (T ₃)	6.41 $\pm$ 0.01 ^{abA}	6.43 $\pm$ 0.01 ^{abAB}	6.45 $\pm$ 0.01 ^{abB}	6.51 $\pm$ 0.02 ^{abC}
Moisture (%)				
NC (T ₁)	77.10 $\pm$ 1.28 ^{aC}	76.18 $\pm$ 1.28 ^{abB}	75.70 $\pm$ 1.34 ^{aAB}	73.96 $\pm$ 1.45 ^{aA}
PC (T ₂)	78.54 $\pm$ 0.57 ^{abB}	78.24 $\pm$ 0.64 ^{abB}	77.44 $\pm$ 0.86 ^{abA}	76.69 $\pm$ 1.09 ^{abA}
GE (T ₃)	80.20 $\pm$ 0.36 ^{abC}	79.62 $\pm$ 0.38 ^{abC}	77.70 $\pm$ 0.39 ^{abB}	75.92 $\pm$ 0.50 ^{abA}
Cooked Vanaraja thigh				
pH				
NC (T ₁)	6.34 $\pm$ 0.01 ^{aA}	6.39 $\pm$ 0.11 ^{aA}	6.42 $\pm$ 0.02 ^{abB}	6.46 $\pm$ 0.01 ^{abB}
PC (T ₂)	6.39 $\pm$ 0.02 ^{abA}	6.41 $\pm$ 0.02 ^{abAB}	6.43 $\pm$ 0.01 ^{abB}	6.47 $\pm$ 0.02 ^{abC}
GE (T ₃)	6.38 $\pm$ 0.04 ^{abA}	6.40 $\pm$ 0.01 ^{abB}	6.46 $\pm$ 0.25 ^{abBC}	6.50 $\pm$ 0.04 ^{abC}
Moisture (%)				
NC (T ₁)	60.67 $\pm$ 0.28 ^{aC}	59.77 $\pm$ 0.52 ^{abC}	58.67 $\pm$ 0.50 ^{abB}	56.61 $\pm$ 0.76 ^{aA}
PC (T ₂)	62.23 $\pm$ 0.40 ^{abC}	61.77 $\pm$ 0.21 ^{abB}	60.41 $\pm$ 0.22 ^{abA}	60.19 $\pm$ 0.12 ^{abA}
GE (T ₃)	62.25 $\pm$ 0.36 ^{abB}	62.07 $\pm$ 0.35 ^{abB}	61.19 $\pm$ 0.36 ^{abA}	60.81 $\pm$ 0.14 ^{abA}

Mean $\pm$ SE with lower case letter column-wise and upper case letter row-wise with different superscript differ significantly ($P \leq 0.05$)

N = 6

Microbiological quality

Total plate count of raw and cooked G.E treated samples was significantly ($P \leq 0.05$) lower than positive control and naive control. Gordon (1996) [33] reported that the reduction in TPC of GE treated samples in our experiment might be due the isothiocyanates present in ginger. During storage, an overall increase in total plate count was observed in all the treatments including control and the increase was significantly ($P \leq 0.05$) for all days.. TPC in our experiment are in agreement Reshi *et al.* (2017) [18] who has reported that the mean total plate count of Ginger Extract treated sausages were significantly ($P \leq 0.05$) lower than control. Sunilson *et al.*, (2009) [34] and Muthulakshmi *et al.*, (2018) [32]. Coliform count of raw and

cooked G.E treated samples was significantly ($P \leq 0.05$) lower than both controls. Reduction in coliform count of GE treated samples in our experiment might be due to antibacterial property of G.E. During storage, coliform counts were not detected on 0th day in any of the samples. Coliform counts showed growth after day 7 and day 14 in raw and cooked samples, respectively. Verma *et al.* (2018) [22] who has reported that with the progress in the storage period, there was a significant ($P \leq 0.05$) increase in the mean coliform count of control and treated sausages. The yeast and mould count of G.E treated samples was significantly ($P \leq 0.05$) lower than positive control and naive control. Reduction in YMC of GE treated samples in our experiment might be due to the possible

antifungal properties of ginger. The yeast and mould were detected only on 21st day of storage in all the treatments. The results are in agreement with Reshi *et al.* (2017)^[18] who have reported that the yeast and Mould counts (YMC) of Ginger

Extract treated sausages were significantly ($P \leq 0.05$) lower than control. Similar results were reported by Bhat *et al.* (2014)^[30], who have detected no yeasts and moulds up to Day 14 of storage.

Table 4: Effect of storage period on total plate count, coliform count and yeast and mould count of raw and cooked Vanaraja thigh during refrigerated storage ($4 \pm 1^\circ\text{C}$)

Treatments	Storage period (days)			
	0	7	14	21
Raw Vanaraja thigh				
Total plate count ($\log_{10}\text{cfu/g}$)				
NC (T ₁)	2.28 $\pm$ 0.01 ^{cA}	2.72 $\pm$ 0.14 ^{cB}	3.49 $\pm$ 0.16 ^{cC}	4.30 $\pm$ 0.03 ^{cD}
PC (T ₂)	2.00 $\pm$ 0.01 ^{bA}	2.21 $\pm$ 0.04 ^{bB}	3.05 $\pm$ 0.02 ^{bC}	3.89 $\pm$ 0.22 ^{bD}
GE (T ₃)	0.94 $\pm$ 0.02 ^{aA}	1.12 $\pm$ 0.04 ^{aB}	2.10 $\pm$ 0.05 ^{aC}	2.96 $\pm$ 0.01 ^{aD}
Coliform count ($\log_{10}\text{cfu/g}$)				
NC (T ₁)	N.D	1.02 $\pm$ 0.02 ^{cA}	1.85 $\pm$ 0.08 ^{cB}	2.06 $\pm$ 0.01 ^{bC}
PC (T ₂)	N.D	0.68 $\pm$ 0.10 ^{bA}	1.35 $\pm$ 0.20 ^{bB}	2.25 $\pm$ 0.23 ^{bC}
GE (T ₃)	N.D	0.37 $\pm$ 0.01 ^{aA}	0.97 $\pm$ 0.02 ^{aB}	1.69 $\pm$ 0.02 ^{aC}
Yeast and mould count ($\log_{10}\text{cfu/g}$)				
NC (T ₁)	N.D	N.D	N.D	2.09 $\pm$ 0.00 ^c
PC (T ₂)	N.D	N.D	N.D	1.95 $\pm$ 0.02 ^{^b}
GE (T ₃)	N.D	N.D	N.D	0.94 $\pm$ 0.01 ^{^a}
Cooked Vanaraja thigh				
Total plate count ($\log_{10}\text{cfu/g}$)				
NC (T ₁)	1.28 $\pm$ 0.01 ^{cA}	2.12 $\pm$ 0.29 ^{bB}	3.15 $\pm$ 0.07 ^{cC}	3.30 $\pm$ 0.03 ^{bC}
PC (T ₂)	1.08 $\pm$ 0.02 ^{bA}	1.21 $\pm$ 0.04 ^{aB}	2.06 $\pm$ 0.28 ^{bC}	2.22 $\pm$ 0.01 ^{aD}
GE (T ₃)	0.77 $\pm$ 0.00 ^{aA}	0.92 $\pm$ 0.04 ^{aB}	1.23 $\pm$ 0.03 ^{aC}	2.06 $\pm$ 0.02 ^{aD}
Coliform count ($\log_{10}\text{cfu/g}$)				
NC (T ₁)	N.D	N.D	0.98 $\pm$ 0.00 ^{cA}	1.06 $\pm$ 0.01 ^{cB}
PC (T ₂)	N.D	N.D	0.74 $\pm$ 0.07 ^{bA}	0.92 $\pm$ 0.04 ^{bB}
GE (T ₃)	N.D	N.D	0.37 $\pm$ 0.04 ^{aA}	0.69 $\pm$ 0.02 ^{aB}
Yeast and mould count ($\log_{10}\text{cfu/g}$)				
NC (T ₁)	N.D	N.D	N.D	1.87 $\pm$ 0.01 ^{^c}
PC (T ₂)	N.D	N.D	N.D	1.54 $\pm$ 0.03 ^{^b}
GE (T ₃)	N.D	N.D	N.D	0.90 $\pm$ 0.01 ^{^a}

Mean $\pm$ SE with lower case letter column-wise and upper case letter row-wise with different superscript differ significantly ($P \leq 0.05$)

*N = 6

Sensory evaluation

The results of sensory scores of both raw and cooked samples decreased with storage period for all attributes but remained acceptable throughout the period. The sensory attributes were significantly affected during 21 days of refrigerated storage. Sensory attributes in our experiment are in agreement. Narsaiah *et al.* (2011)^[35] who found tenderness scores significantly higher in papain followed by PSP and blade incised samples

than control. Naveena and Mendiratta (2010)^[6] found that there was a significant ($P \leq 0.01$) increase in tenderness scores in G.E treated sample compared to the control. Increase in tenderness scores with increased concentration of GE can be correlated with reduced shear force values. Improvement in tenderness scores of all GE treated samples is inconsistent with the findings of Lee *et al.* (1986)^[23] and Naveena and Mendiratta (2010)^[6].

Table 5: Effect of storage period on sensory attributes of raw and cooked Vanaraja thigh during refrigerated storage ($4 \pm 1^\circ\text{C}$)

Treatments	Storage period (days)			
	0	7	14	21
Raw Vanaraja thigh				
Appearance				
NC (T ₁)	7.28 $\pm$ 0.18 ^{aB}	7.14 $\pm$ 0.26 ^{aB}	6.85 $\pm$ 0.14 ^{aA}	6.57 $\pm$ 0.29 ^{aA}
PC (T ₂)	7.14 $\pm$ 0.26 ^{aC}	7.14 $\pm$ 0.14 ^{aC}	6.71 $\pm$ 0.28 ^{aB}	5.85 $\pm$ 0.40 ^{aA}
GE (T ₃)	7.28 $\pm$ 0.11 ^{aB}	7.18 $\pm$ 0.18 ^{aAB}	7.00 $\pm$ 0.21 ^{bA}	7.00 $\pm$ 0.01 ^{cA}
Tenderness				
NC (T ₁)	6.99 $\pm$ 0.11 ^{aA}	7.11 $\pm$ 0.09 ^{aA}	7.71 $\pm$ 0.09 ^{bB}	7.97 $\pm$ 0.36 ^{bB}
PC (T ₂)	7.54 $\pm$ 0.11 ^{^b}	7.65 $\pm$ 0.31 ^{^b}	7.71 $\pm$ 0.51 ^{^b}	7.75 $\pm$ 0.91 ^{^b}
GE (T ₃)	7.07 $\pm$ 0.31 ^{^b}	7.17 $\pm$ 0.19 ^{^b}	7.19 $\pm$ 0.11 ^{^a}	7.20 $\pm$ 0.11 ^{^a}
Colour				
NC (T ₁)	7.00 $\pm$ 0.20 ^{aB}	7.00 $\pm$ 0.30 ^{aB}	6.48 $\pm$ 0.18 ^{aA}	6.42 $\pm$ 0.42 ^{aA}
PC (T ₂)	7.57 $\pm$ 0.30 ^{bB}	7.05 $\pm$ 0.37 ^{aB}	6.71 $\pm$ 0.35 ^{aAB}	6.44 $\pm$ 0.36 ^{aA}
GE (T ₃)	7.57 $\pm$ 0.21 ^{bB}	7.11 $\pm$ 0.20 ^{bB}	7.00 $\pm$ 0.19 ^{bB}	6.57 $\pm$ 0.20 ^{bA}
Cooked Vanaraja thigh				
Appearance				

NC (T ₁)	7.08±0.18 ^{aC}	7.14±0.26 ^{aC}	6.57±0.29 ^{aB}	5.00±0.16 ^{aA}
PC (T ₂)	7.14±0.26 ^{aB}	7.07±0.11 ^{aB}	6.85±0.14 ^{aB}	5.85±0.26 ^{bA}
GE (T ₃)	7.28±0.18 ^{aB}	7.13±0.20 ^{aB}	7.11±0.14 ^{bAB}	6.57±0.29 ^{cA}
Flavour				
NC (T ₁)	7.00±0.30 ^{aB}	6.57±0.28 ^{aAB}	5.71±0.52 ^{aA}	5.21±0.72 ^{aA}
PC (T ₂)	7.00±0.37 ^{aB}	6.71±0.35 ^{aAB}	6.42±0.11 ^{bAB}	6.00±0.11 ^{bA}
GE (T ₃)	7.85±0.18 ^{bB}	7.57±0.20 ^{bAB}	7.00±0.30 ^{cA}	6.92±0.01 ^{aA}
Tenderness				
NC (T ₁)	6.85±0.14 ^a	6.85±0.18 ^a	6.86±0.40 ^a	6.91±0.28 ^a
PC (T ₂)	7.71±0.20 ^a	7.77±0.21 ^a	7.80±0.28 ^a	7.80±0.29 ^a
GE (T ₃)	7.07±0.18 ^b	7.09±0.20 ^b	7.10±0.21 ^b	7.11±0.00 ^{ab}
Juiciness				
NC (T ₁)	7.00±0.21 ^{aC}	6.71±0.35 ^{aB}	6.71±0.28 ^{aB}	5.85±0.34 ^{aA}
PC (T ₂)	7.11±0.26 ^{aC}	6.85±0.34 ^{abBC}	6.74±0.35 ^{aB}	5.57±0.36 ^{aA}
GE (T ₃)	7.14±0.26 ^{aB}	7.14±0.21 ^{bB}	7.02±0.20 ^{bB}	6.14±0.26 ^{bA}
Overall Acceptability				
NC (T ₁)	7.28±0.28 ^{aB}	7.00±0.14 ^{aB}	6.71±0.21 ^{aB}	5.00±0.53 ^{aA}
PC (T ₂)	7.42±0.14 ^{aB}	7.40±0.11 ^{bB}	7.28±0.18 ^{bB}	6.42±0.16 ^{bA}
GE (T ₃)	7.42±0.20 ^{aB}	7.38±0.13 ^{bB}	7.16±0.14 ^{bA}	7.14±0.14 ^{cA}

Mean ± SE with lower case letter column-wise and upper case letter row-wise with different superscript differ significantly ($P \leq 0.05$)

* 8-point descriptive scale (8 = extremely desirable, 1 = extremely undesirable)

Conclusions

The study revealed that the quality of Vanaraja spent hen meat changed desirably with an improvement in tenderness, microbiological and sensory parameters. It was further observed that the best quality product was obtained when the sample was treated with 6% ginger rhizome extract. Therefore, a technology for utilization of easily and cheaply available ginger can be exploited at the industrial or household level for tenderization of less palatable Vanaraja spent hen meat and thus a protein rich meat can be made available to masses from otherwise layer industry waste.

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