



# A comparative study of intramuscular fat content and sensory attributes of meat of broiler and Kuttanad ducks<sup>#</sup>

J. Alphine<sup>1</sup>, S. Maya<sup>2\*</sup>, N. Ashok<sup>3</sup>, K. M. Lucy<sup>4</sup>, Indu V. Raj<sup>5</sup>,

K. Karthiayini<sup>6</sup>, V. N. Vasudevan<sup>7</sup> and J. Tony<sup>8</sup>

Department of Veterinary Anatomy

College of Veterinary and Animal Sciences, Mannuthy, Thrissur- 680 651

Kerala Veterinary and Animal Sciences University

Kerala, India

Citation: Alphine, J., Maya, S., Ashok, N., Indu, V.R., Lucy, K.M., Karthiayini, K., Vasudevan, V.N. and Tony, J. 2023. A comparative study of intramuscular fat content and sensory attributes of meat of broiler and Kuttanad ducks. *J. Vet. Anim. Sci.* **54**(3):744-754

DOI: <https://doi.org/10.51966/jvas.2023.54.3.744-754>

Received: 13.02.2023

Accepted: 17.02.2023

Published: 30.09.2023

## Abstract

Meat samples from six regions viz., neck, wing, breast, back, thigh and drumstick were collected from a total of 72 ducks comprising of six males and females of each of Vigova broilers, Kuttanad ducklings and spent Kuttanad ducks. The samples were assessed by a trained panel of seven assessors for flavour, juiciness, ease of fragmentation, mouth coating, overall tenderness and overall acceptability on eight-point Hedonic scale. Intramuscular fat of meat from the six regions was also estimated using Soxhlet apparatus. The highest mean intramuscular fat was obtained in the neck muscle by the spent Kuttanad ducks females ( $p < 0.01$ ) and the lowest mean intramuscular fat content was obtained for Kuttanad ducklings females in the breast region ( $p < 0.01$ ). The mean flavour scores did not differ significantly between groups except in the thigh region. There was no significant difference observed in the juiciness and mouth coating score between groups and genders. The highest mean ease of fragmentation score was attained in the back region for broiler duck males. The overall tenderness score showed significant difference ( $p < 0.05$ ) in breast muscle and back muscles. The overall tenderness score was significantly higher in broiler ducks in the back region. Overall acceptability score was significantly highest in back muscle followed

<sup>#</sup>Part of Ph. D thesis submitted to Kerala Veterinary and Animal Sciences University, Pookode, Wayanad, Kerala

1. Ph. D Scholar
2. Professor and Head
3. Senior Professor and University Head
4. Professor
5. Professor and Controller of Examinations
6. Professor, Department of Veterinary Physiology
7. Associate Professor and Head, Department of Livestock Products Technology
8. Veterinary Surgeon, Central Hatchery, Chengannur

\*Corresponding author: maya@kvasu.ac.in, Ph. 9446625160

Copyright: © 2023 Alphine *et al.* This is an open access article distributed under the terms of the Creative Commons Attribution 4.0 International License (<http://creativecommons.org/licenses/by/4.0/>), which permits unrestricted use, distribution, and reproduction in any medium, provided the original author and source are credited.

*by breast muscle in broiler ducks compared to spent Kuttanad ducks and was comparable to Kuttanad ducklings.*

**Keywords:** *Broiler ducks, intramuscular fat, Kuttanad ducks, meat quality traits, sensory evaluation*

Duck meat is categorised as poultry meat along with chicken, turkey and other poultry; however, its physicochemical characteristics and muscle fibre composition markedly differ from others (Kim *et al.*, 2008). Duck meat has a reputation for being delicious and aromatic, rich in vital aminoacids, and high in polyunsaturated fatty acids (Olayiwola, 2006). Without skin, it contains less fat and calorie content. The fat is comparable to olive oil which helps to decrease blood cholesterol levels. Sreekumar *et al.* (2007) compared the haematological and biochemical parameters of young and adult drakes and found that the cholesterol level was numerically higher in adult drakes than the young ones. The consumption of white meat and duck meat is gaining more attention as a result of recommendations to cut back on red meat intake due to its link to cardiovascular diseases (Witak, 2008). With the exception of Kerala, duck meat has not yet attracted much popularity in the country despite being valued for its flavour and nutritional benefits.

Meat quality has always been a concern for consumers and meat industry alike. Skeletal muscle and connective tissue components comprise the majority of the meat whose proportions in turn would decide the quality. There were age-related increases in the fibre area, size and concentration of haematinic pigments in duck muscle (Baeza *et al.*, 1997). Due to the large muscle fibre size, parameters like the amount of collagen in meat, the mellowness and tenderness of the muscle reduced with age. According to Baeza *et al.* (1998), the age of ducks causes the meat quality to decline. The meat losses juiciness and becomes tougher (less tender), which is related to increased collagen cross-linking and thicker muscle fibres. In both cattle (Renand *et al.*, 2001) and pigs (Karlsson *et al.*, 1993) muscles with a larger fibre size, especially type IIB fibre, display tougher meat than muscles with a smaller fibre

size. Taylor (2004) reported that type IIB fibre has a negative correlation with juiciness and flavour. Flavour, texture, juiciness, tenderness, and meat palatability has a direct impact on consumer satisfaction and meat quality (Behrends *et al.*, 2005; Calkins and Hodgen, 2007). Biswas *et al.* (2006) demonstrated that there was a significant relationship between the organoleptic assessment scores of the duck sausages with regard to the amount of time they were kept at room temperature and in the refrigerator. Correlation studies comparing raw and pre-cooked spent hen breast-meat showed that the flavour of meat influence the overall acceptance of both raw and cooked meat. As a result, as pre-cooked flavour diminishes, its sensory rating for other traits also decreases (Sreenivasaiah *et al.*, 1988).

Li *et al.* (2007) noted that in the sensory test, organic duck outperformed broiler chicken in terms of texture, odour, softness, and flavour. Sindelar *et al.* (2007) suggested that colour, juiciness, flavour, and roughness or tenderness are the four factors influencing consumer purchasing decisions. Moreover, the differences in breeds and muscles influence colour, juiciness, texture, flavour and taste of poultry products (Majewska *et al.*, 2009; Muhlisin *et al.*, 2013). Li *et al.* (2013) reported that the hardness of duck meat increased when cooked at internal meat temperatures of 40 to 50°C and 60 to 95°C. The structure of the duck meat is squeezed during boiling due to shrinkage of the muscle fibres and connective tissue. In both phases of enhanced hardness, there is a correlation between the modifications to myofibrillar proteins and their solubility. Tanganyika and Webb (2019) stated that, in relation to post-mortem ageing period, the best meat obtained was cooked by grilling or after 12 h post-mortem ageing period for better sensorial attributes of colour, tenderness and juiciness. However, upon various sensory attributes of native Kuttanad and meat type broiler ducks, little is known till now compared with other species. Therefore, the present study is aimed to compare the sensory properties of cooked meat of broiler and Kuttanad ducks and to correlate the organoleptic evaluation with the intramuscular fat content of the experimental groups.

## Materials and methods

### Sample collection

Comparative sensory analysis of meat of broiler and Kuttanad ducks was done at the Department of Veterinary Anatomy, College of Veterinary and Animal Sciences (CVAS), Mannuthy. A total of 72 birds comprising twelve birds belonging to either sex from each of Vigova Super M broiler ducks aged six to eight weeks, Kuttanad ducks aged six to eight weeks and spent Kuttanad ducks aged above 72 weeks selected at random were used for the study. The Vigova SuperM (White Pekin x Aylesbury) were purchased from M/s Moon Valley farm, Marathakkara whereas Kuttanad ducks from UPDF, Mannuthy. The study was approved by the Institutional Animal Ethics Committee and all procedures were performed in accordance with the guidelines of Committee for the Purpose of Control and Supervision of Experiments on Animals for birds.

### Intramuscular fat content

Intramuscular fat content (IMF) as per cent of skeletal muscle was estimated as per AOAC (1995). Fat content of about three grams of moisture free sample was extracted in petroleum ether (Boiling range 40-60°C) using socs plus solvent extraction system (Pelican Equipments, India). Ether extract obtained was dried to a constant weight at 100°C, cooled and weighed. Fat content on dry matter basis was converted to wet matter basis and expressed as per cent of the duck meat.

All the beakers were rinsed and placed in an oven set at a temperature of 100°C along with the samples. After removal of the moisture, the beakers were placed in a dessicator for five to 10 min to bring them to room temperature. An empty beaker was weighed and the weight ( $W_1$ ) was recorded as the initial beaker weight (IBW). A thimble was inserted in the thimble holder and placed in the beaker. The samples were weighed (SW) and one to two grams were transferred to the thimble. The solvent (80 ml) was then poured into the beaker. All the beakers were loaded in the system. The system was switched on and the boiling temperature was set. The boiling temperature was set to be 20°C

more than that of the solvent's maximum boiling point. The process was set to run for 60 minutes. After the process time, the temperature was increased to recovery temperature (max boiling point x 2). Rinsing was done two to three times to collect the remaining fat, if any, in the sample/thimble. All the beakers were taken out from the system, the thimbles removed and the beakers placed into a hot air oven at 100°C. After 20 to 30 minutes, all the beakers were taken out; placed in a desiccator for 10 to 15 minutes, to cool them to room temperature; and weighed for recording the final weight ( $W_2$ ) of the beaker (FBW). The percentage of fat present in the sample was calculated as follows:

$$\text{Intramuscular Fat (per cent)} = \frac{W_2 - W_1}{SW} \times 100$$

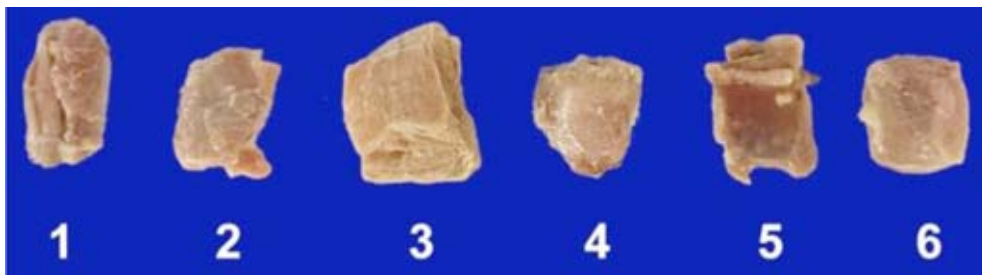
### Meat quality traits

The organoleptic evaluation of cooked duck meat from neck, wing, breast, back, thigh and drumstick were conducted by a semi-trained (n=7) taste panel composed of postgraduate students from the Department of Livestock Products Technology, College of Veterinary and Animal Sciences, Mannuthy. They were briefed on the nature of the experiment without disclosing the identity of samples. Meat samples used were of approximately equal size (1.5×1.5×1.9 cm) and cooked by indirect pressure cooking in small stainless-steel boxes (Figs. 1 & 2). Cooking was initially done under high flame until the first whistle and subsequently under low flame for 30 min. Each panellist received one cube of cooked duck meat with three-digit code number and score card (AMSA, 1983). The panellists were asked to rate the samples using an eight-point hedonic scale. They were provided with filtered water to cleanse their palate in between samples during evaluation. The samples were evaluated for flavour, juiciness, ease of fragmentation, mouth coating, overall tenderness and overall acceptability.

All data were analysed by the two-way ANOVA model followed by Duncan's multiple-range tests using SPSS 24.0 for Windows statistical software package (Statistical Product and Service Solutions, Inc., USA) with each



**Fig. 1.** Muscles from selected region before cooking. 1. Neck, 2. Wing, 3. Breast, 4. Back, 5. Thigh, 6. Drumstick



**Fig. 2.** Muscles from selected region after cooking. 1. Neck, 2. Wing, 3. Breast, 4. Back, 5. Thigh, 6. Drumstick

duck as the experimental unit. As meat quality traits evaluation variables are subjective parameters, non-parametric test was done for further comparison. Between group comparison within male and female was done separately by using Kruskal Walli's ANOVA and between gender comparison within each group was done by using Mann Whitney U test. Probability levels, viz. Pb 0.01 and Pb 0.05 were used to assess statistical significance and trends among means, respectively.

## Results and discussion

### Intramuscular fat content

The mean intramuscular fat content showed significant interaction in all the muscles (Table 1). The highest mean intramuscular fat was obtained in the neck muscle by the spent Kuttanad ducks females ( $p < 0.01$ ) (Fig. 3). This might be due to the increased proportion of type I fibre types. Calkins *et al.* (1981) stated that in cattle, the proportion of type I fibre was positively associated with the intramuscular fat (IMF) content. The lowest mean intramuscular fat content was obtained for Kuttanad ducklings females in the breast region ( $p < 0.01$ ). These findings were in consonance with the experiment by Huda *et al.* (2011) in which the proximate composition of Pekin and Muscovy

duck were compared and it was detected that fat content was lesser in the breast and protein content was higher in thigh muscle. In the breast muscle, the mean intramuscular fat content did not differ significantly between males. Spent Kuttanad ducks showed higher intramuscular fat content in both males and females in all the regions studied. These findings were in accordance with Kokoszynski *et al.* (2021), where the authors noticed that the native Polish Pekin ducks had a breast muscle crude fat content that was much greater than broiler Pekins.

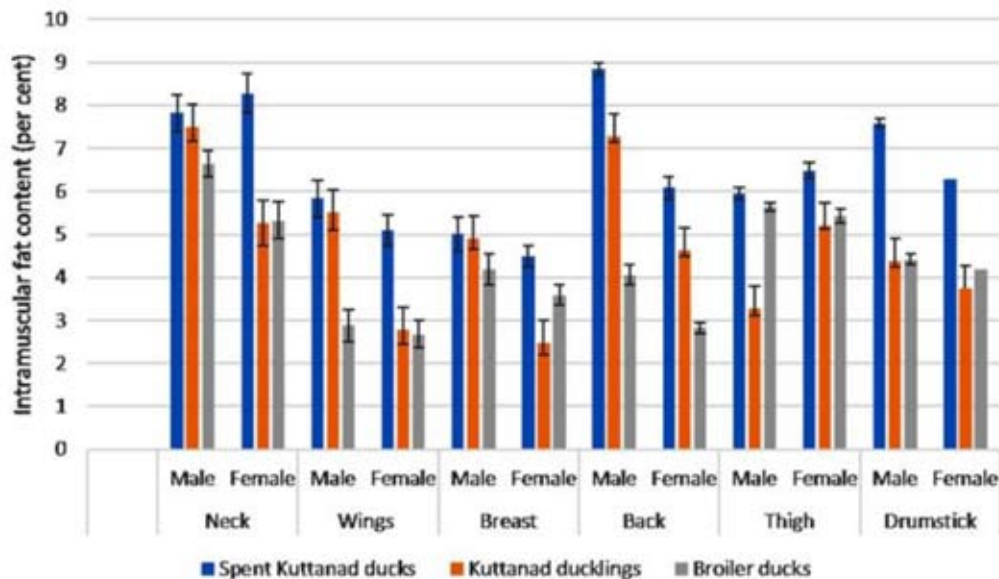
### Meat quality traits

The meat quality attributes of cooked meat of spent Kuttanad ducks, Kuttanad ducklings and broiler ducks were evaluated using an eight-point Hedonic scale.

The mean flavour scores did not differ significantly between groups except in the thigh region in males (Fig. 4). Among all the muscles, the highest mean flavour was shown in the thigh muscle by broiler ducks males ( $p < 0.05$ ). The flavour score of broiler duck males was similar to spent Kuttanad ducks males in the thigh region; and also, significantly higher than Kuttanad ducklings. In a study related to the sensory characteristics of duck meat, it was

found that the flavour was positively correlated with lipid content (Chartrin *et al.*, 2006) and the higher fat content might cause the stronger flavour in duck meat. In the present study, the

intramuscular fat content was higher in male broiler ducks for the thigh region, was similar for male spent Kuttanad ducks.



**Fig. 3.** Intramuscular fat content (per cent) of skeletal muscle of spent Kuttanad ducks, Kuttanad ducklings and broiler ducks

**Table 2.** Intramuscular fat content between groups and sexes (Mean±S.E.), per cent

Regions	Sex	Spent Kuttanad ducks	Kuttanad ducklings	Broiler ducks	p-value		
					G	S	G x S
Neck (Longus colli posticus)	Male	7.82 ± 0.62 <sup>aB</sup>	7.51 ± 0.35 <sup>bA</sup>	6.64 ± 0.29 <sup>cA</sup>	0.001 (**)	<0.001 (**)	<0.001 (**)
	Female	8.28 ± 0.42 <sup>aA</sup>	5.26 ± 0.33 <sup>bB</sup>	5.33 ± 0.31 <sup>bB</sup>			
Wing (Biceps brachii)	Male	5.84 ± 0.45 <sup>a</sup>	5.52 ± 0.52 <sup>aA</sup>	2.88 ± 0.42 <sup>b</sup>	<0.001 (**)	0.002 (**)	0.017 (*)
	Female	5.09 ± 0.43 <sup>a</sup>	2.78 ± 0.42 <sup>bB</sup>	2.68 ± 0.38 <sup>b</sup>			
Breast (Pectoralis)	Male	5.01 ± 0.36 <sup>A</sup>	4.9 ± 0.34 <sup>A</sup>	4.19 ± 0.31	0.831 (ns)	<0.001 (**)	0.012 (*)
	Female	4.48 ± 0.40 <sup>aB</sup>	2.48 ± 0.25 <sup>bB</sup>	3.59 ± 0.35 <sup>a</sup>			
Back (Scapulo humeralis caudalis)	Male	8.85 ± 0.25 <sup>aA</sup>	7.29 ± 0.28 <sup>bA</sup>	4.06 ± 0.24 <sup>c</sup>	<0.001 (**)	<0.001 (**)	<0.001 (**)
	Female	6.08 ± 0.15 <sup>aB</sup>	4.63 ± 0.16 <sup>b</sup>	2.83 ± 0.24 <sup>cB</sup>			
Thigh (Iliofibularis)	Male	5.95 ± 0.27 <sup>aB</sup>	3.27 ± 0.15 <sup>bB</sup>	5.64 ± 0.12 <sup>aA</sup>	<0.001 (**)	<0.001 (**)	<0.001 (**)
	Female	6.49 ± 0.14 <sup>aA</sup>	5.22 ± 0.15 <sup>bA</sup>	5.43 ± 0.10 <sup>bB</sup>			
Drumstick (Gastrocnemius lateralis)	Male	7.59 ± 0.17 <sup>aA</sup>	4.38 ± 0.10 <sup>b</sup>	4.42 ± 0.16 <sup>b</sup>	<0.001 (**)	0.739 (**)	<0.001 (**)
	Female	6.29 ± 0.09 <sup>aB</sup>	3.74 ± 0.13 <sup>c</sup>	4.19 ± 0.12 <sup>b</sup>			

\*\* Significant at 0.01 level; \* Significant at 0.05 level; ns non-significant

Means having different lower case letter as superscript differ significantly within a row

Means having different upper case letter as superscript differ significantly within a column for each parameter

In both spent Kuttanad ducks and Kuttanad ducklings, flavour score of thigh muscles of females were higher than males without significant difference. Similarly intramuscular fat content also showed higher IMF in females compared to males in these two groups. The least flavour among different regions noticed were also in thigh muscle by Kuttanad duckling males. In the present study intramuscular fat content was comparatively lowest in the thigh muscle of the Kuttanad duckling male. Qiao *et al.* (2017) aimed to compare meat quality characteristics of Cherry Valley, Spent Layer and Crossbred ducks and found that the intramuscular fat and polyunsaturated fatty acids were involved in producing intense aroma and flavour of duck meats. In females, spent Kuttanad ducks showed significantly higher intramuscular fat content than broiler ducks and Kuttanad ducklings. In females, the flavour score did not differ between groups. Also, Shorthose and Harris (1991) noted that the customers felt the meat as juicy and flavourful if it was tender.

There was no variation in juiciness score observed between groups and genders (Fig. 5). Juiciness of meat was determined by the combination of different factors viz a viz intramuscular fat content, moisture content, collagen content and cross-sectional area of fibres as coined by Forrest *et al.* (1975) and Baeza *et al.* (1998). According to Baeza *et al.* (1998), the quality and palatability of breast muscles of Muscovy ducks deteriorated with age. They become less juicy and more tough which was connected with decreased collagen

of muscle fibres. Various combination of these factors may produce almost same juiciness in various muscles.

### Ease of fragmentation

There was significant difference for the mean ease of fragmentation score in back and thigh regions between groups ( $p < 0.05$ ) (Fig. 6). In the back region, the highest mean ease of fragmentation score was obtained for broiler duck males, which was significantly different from Kuttanad ducklings, but was similar to spent Kuttanad ducks. In the thigh region, males showed significant difference where the ease of fragmentation score was significantly highest for broiler ducks males than Kuttanad ducklings and similar to spent Kuttanad ducks. Gender wise significant difference was noticed in the drumstick muscle by Kuttanad ducklings with females score more than males. Comparing different regions, the highest ease of fragmentation score was noticed in breast muscle of broiler ducks females. The lowest mean ease of fragmentation score was shown in drumstick muscle of Kuttanad duckling males. Similarly, thigh muscle of Kuttanad ducklings showed very low score for ease of fragmentation. Gibin (2013) stated that due to the higher connective tissue content in Kuttanad duck meat as a result of the older slaughter age, Vigova meat scored higher value for ease of fragmentation and the breast meat was more easily fragmented than the thigh meat. In the present study breast muscle of broiler ducks showed the highest score for ease of fragmentation.

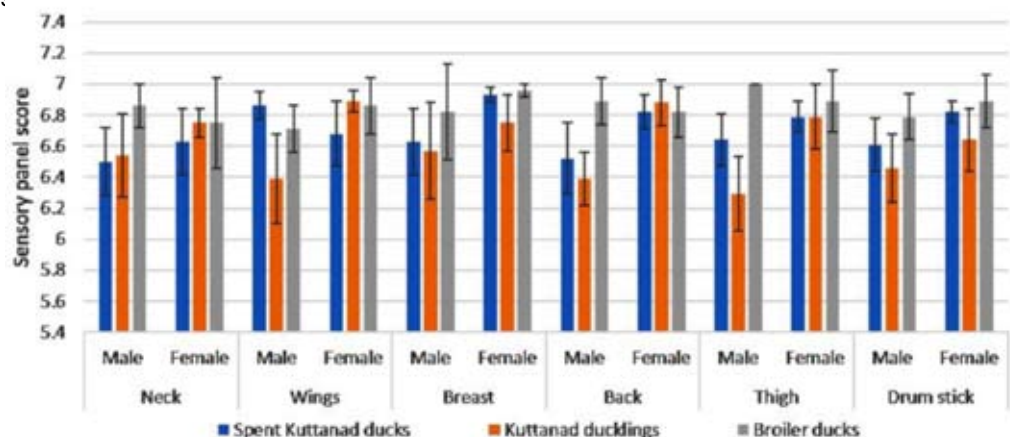


Fig. 4. Flavour score of spent Kuttanad ducks, Kuttanad ducklings and broiler ducks



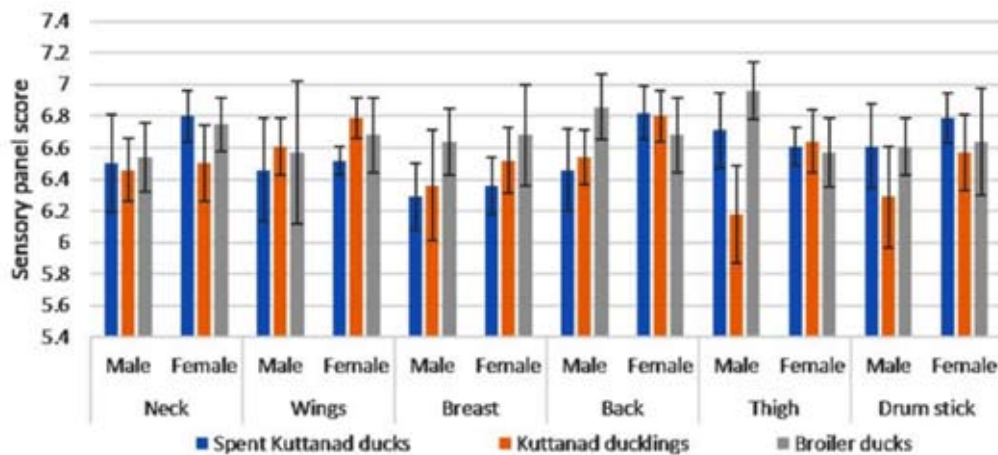


Fig. 5. Juiciness score of spent Kuttanad ducks, Kuttanad ducklings and broiler ducks

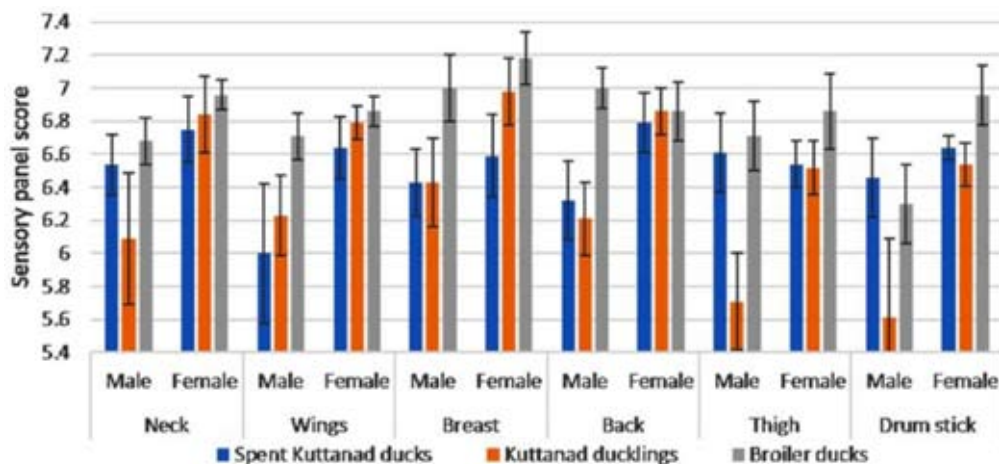


Fig. 6. Ease of fragmentation score of spent Kuttanad ducks, Kuttanad ducklings and broiler ducks

There were no significant differences in the mean mouth coating between groups and between genders among all the regions under study (Fig. 7). On the contrary, Gibin (2013), observed that there was a significant difference in the amount of connective tissue remaining after chewing (mouth coating) between Vigova and Kuttanad ducks. Highest score (least mouth coating) was obtained for Vigova breast and lowest for Kuttanad thigh. The connective tissue left over after the majority of the sample had been chewed up was known as residue after chewing. This was brought in by the coarse connective tissue strands in the perimysium or epimysium. Aged animals exhibited a greater strength of connective tissue in their muscles (Forrest *et al.*, 1975).

The overall tenderness score showed

significant difference in breast muscle and back muscle among the male groups ( $p < 0.05$ ) (Fig. 8). Male broiler ducks presented highest overall tenderness in the back region. Comparing different regions, the neck muscle of broiler ducks also given highest overall tenderness without any significant difference between other groups and found similar to the score of male broiler ducks in the back muscle. In back region, overall tenderness was significantly higher in broiler ducks with similarity towards spent Kuttanad ducks and differences towards Kuttanad ducklings. Overall tenderness score showed gender difference in the back region in Kuttanad ducklings where the female meat was more tender than males. The overall tenderness score was significantly higher in broiler ducks males than spent Kuttanad ducks and similar to Kuttanad duckling in the breast

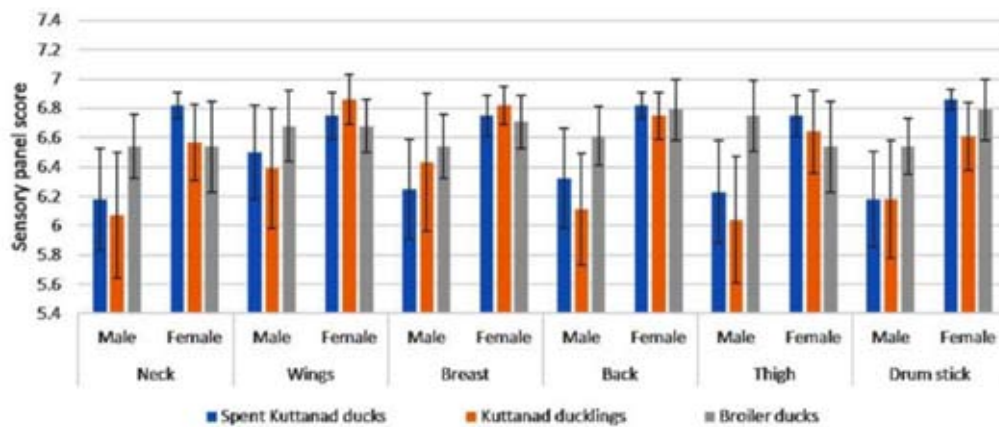


Fig. 7. Mouth coating score of spent Kuttanad ducks, Kuttanad ducklings and broiler ducks

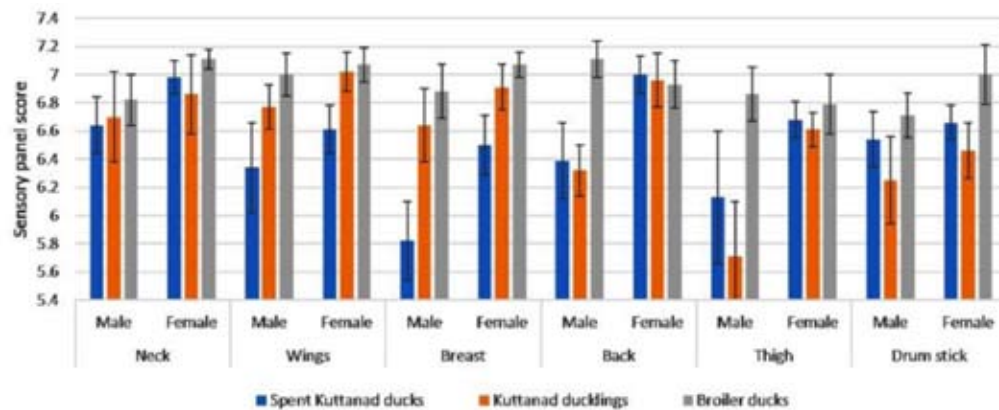


Fig. 8. Overall tenderness score of spent Kuttanad ducks, Kuttanad ducklings and broiler ducks

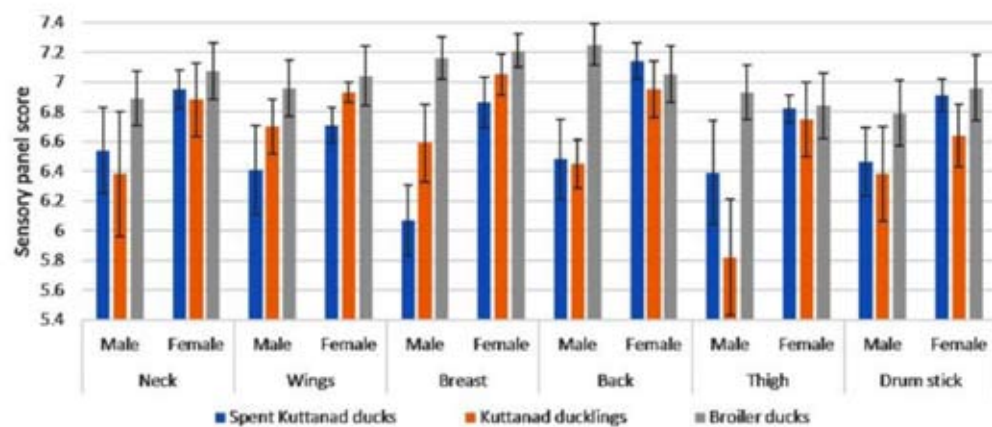


Fig. 9. Overall acceptability score of spent Kuttanad ducks, Kuttanad ducklings and broiler ducks

muscle. In almost all regions' broilers showed higher tenderness than other two groups. Wattanachant *et al.* (2004) noted that the meat of fast-growing genotypes was more tender when compared to slow growing or older birds. The least overall tenderness score was given

by Kuttanad ducklings in the thigh muscle without showing differences between groups and genders. Gibin (2013) noted that while comparing Kuttanad ducks to Vigova ducks, the mean score for overall tenderness was significantly higher for Vigova ducks. Vigova



breast meat received the highest mean score for overall tenderness and Kuttanad thigh meat received the lowest.

Overall acceptability score showed significant difference between males in the breast and back regions ( $p < 0.05$ ) (Fig. 9). In the breast muscle, overall acceptability was significantly higher in broiler ducks compared to spent Kuttanad ducks and similar to Kuttanad ducklings. In the back muscle, broiler ducks showed significantly higher score compared to Kuttanad ducklings and similar to spent Kuttanad ducks. Considering different regions, the highest overall acceptability was given by back region in broiler duck males. The breast muscle of male broiler ducks and female broiler ducks showed relatively higher values too. According to Gibin (2013), mean overall acceptability score was significantly higher for Vigova duck meat when compared to Kuttanad duck meat where the highest score was for Vigova breast meat and lowest for Kuttanad thigh meat. Within a group, breast meat had significantly higher mean overall acceptability score when compared to thigh meat and was due to increased tenderness of breast meat.

## Conclusion

Among all the groups, male broiler ducks displayed highest overall tenderness in the back region. The neck muscle of broiler ducks also showed highest overall tenderness without any significant difference between other groups and were found similar to the score of male broiler ducks in the back muscle. Among all the muscles, the highest mean flavour was shown in the thigh muscle by broiler ducks males. The intramuscular fat content was higher in male broiler ducks for the thigh region which depicted the positive correlation with intramuscular fat and flavour content. Overall, the results showed higher overall acceptability for broiler duck meat compared to spent Kuttanad ducks and Kuttanad ducklings.

## Acknowledgements

The authors duly acknowledge the Directorate of Science and Technology, Delhi for providing financial help in the respect of DST-INSPIRE fellowship during Ph.D. degree

and College of Veterinary and Animal Sciences, Mannuthy (KVASU) for providing materials for this work and Department of Veterinary Anatomy, College of Veterinary and Animal Sciences, Mannuthy for the co-operation rendered during the work period.

## Conflict of interest

The authors declare that they have no conflict of interest

## References

- AMSA [American Meat Science Association]. 1983. *Guidelines for cookery and sensory evaluation of meat*. Chicago, IL: American Meat Science Association, National Livestock and Meat Board. 872p.
- AOAC [Association of Official Analytical Chemists]. 1995. *Official Methods of Analysis*, (16th edn.). Cunniff, P. (Ed.), The Association: Arlington, VA, Washington D.C., U.S.A. 7p.
- Baeza, E., De carville, H., Salichon, M.R., Marche, G. and Leclercq, B. 1997. Effects of selection, over three and four generations on meat yield and fatness in Muscovy ducks. *Br. Poult. Sci.* **38**: 359-365.
- Baeza, E., Salichon, M.R., Marche, G., Juin, H. 1998. Effect of sex on growth, technological and organoleptic characteristics of the Muscovy duck breast muscle. *Br. Poult. Sci.* **39**: 398 - 403.
- Behrends, J.M., Goodson, K.J., Koohmaraie, M., Shackelford, S.D., Wheeler, T.L., Morgan, W.W., Reagan, J.O., Gwartney, B.L., Wise, J.W. and Savell, J.W. 2005. Beef customer satisfaction: USDA quality grade and marination effects on consumer evaluations of top round steaks. *J. Anim. Sci.* **83**: 662-670.
- Biswas, S., Vijayakumar, K.S., Bhattacharyya, D. and Sinhamahapatra, M. 2006. Effect of storage on duck meat sausages. *Int. J. Poult. Sci.* **41**: 234-237.

- Calkins, C.R. and Hodgen, J.M. 2007. A fresh look at meat flavour. *Meat Sci.* **77**: 63-80.
- Calkins, C.R., Dutson, T.R., Smith, G.C., Carpenter, Z.L. and Davis, G.W. 1981. Relationship of fibre type composition to marbling and tenderness of bovine muscle. *J. Food Sci.* **46**: 708-710.
- Chartrin, P., Meteau, K., Juin, H., Bernadet, M. D., Guy, G., Larzul, C., Remignon, H., Mourot, J., Duclos, M.J. and Baeza, E. 2006. Effects of intramuscular fat levels on sensory characteristics of duck breast meat. *Poult. Sci.* **85**: 914-922.
- Forrest, J.C., Aberle, E.D., Hedrick, H.B., Judge, M.D. and Merkal, R.A. 1975. *Principles of Meat Science*. W.H. Freeman and Company, San Francisco, 417p.
- Gibin, T.G. 2013. Comparison of carcass characteristics and meat qualities of Vigova and Kuttanad ducks. *M.V.Sc. thesis*, Kerala Veterinary and Animal Sciences University, Pookode, 50p.
- Huda, N., Putra, A.A. and Ahmad, R. 2011. Proximate and physicochemical properties of Peking and Muscovy duck breasts and thighs for further processing. *J. Food Agric. Environ.* **9**: 82-88.
- Karlsson, A., Enfalt, A.C., Essen-Gustavsson, B., Lundström, K., Rydhmer, L. and Stern, S. 1993. Muscle histochemical and biochemical properties in relation to meat quality during selection for increased lean tissue growth rate in pigs. *J. Anim. Sci.* **71**: 930-938.
- Kim, G.D., Jeong, J.Y., Moon, S.H., Hwang, Y.H., Park, G.B. and Joo, S.T. 2008. Effects of muscle fibre type on meat characteristics of chicken and duck breast muscle. In proceedings of *54th International Congress of Meat Science and Technology (54th ICoMST)*. pp. 10-15.
- Kokoszynski, D., Wilkanowska, A., Saleh, M., Fik, M. and Bigorowski, B. 2021. Comparison of some meat and liver quality traits in Muscovy and Pekin ducks. *J. Applied Anim. Res.* **49**: 118-124.
- Li, C., Wang, D., Xu, W., Gao, F. and Zhou, G. 2013. Effect of final cooked temperature on tenderness, protein solubility and microstructure of duck breast muscle. *Food Sci. Technol.* **51**: 266-274.
- Li, G.H., Choe, I.S., Nam, K.T., Kim, S.H., Lee, C.H. and Choi, K.D. 2007. A study on the appropriateness of duck meat processing according to feeding management. *Food Sci. Anim. Resour.* **27**: 203-208.
- Majewska, D., Jakubowska, M., Ligocki, M., Tarasewicz, Z., Szczerbińska, D., Karamucki, T. and Sales, J. 2009. Physicochemical characteristics, proximate analysis and mineral composition of ostrich meat as influenced by muscle. *Food Chem.* **117**: 207-211.
- Muhlisin, M., Kim, D.S., Song, Y.R., Kim, H.R., Kwon, H.J., An, B.K., Kang, C.W., Kim, H.K. and Lee, S.K. 2013. Comparison of meat characteristics between Korean native duck and imported commercial duck raised under identical rearing and feeding condition. *Food Sci. Anim. Res.* **33**: 89-95.
- Olayiwola, A. 2006. Review Research in Duck of Nutrient Utilization. *Int. J. Poult. Sci.* **5**: 201-218.
- Qiao, Y., Huang, J., Chen, Y., Chen, H., Zhao, L., Huang, M. and Zhou, G. 2017. Meat quality, fatty acid composition and sensory evaluation of Cherry Valley, Spent Layer and Crossbred ducks. *Anim. Sci. J.* **88**: 156-165.
- Renand, G., Picard, B., Touraille, C., Berge, P. and Lepetit, J. 2001. Relationships between muscle characteristics and meat quality traits of young Charolais bulls. *Meat Sci.* **59**: 49-60.
- Shorthose, W.R. and Harris, P.V. 1991. Effects of

- growth and composition on meat quality. In: Growth regulations in farm animals advanced in meat research. *Applied Sci.* **7**: 515-554.
- Sindelar, J.J., Cordray, J.C., Sebranek, J.G., Love, J.A. and Ahn, D.U. 2007. Effects of vegetable juice powder concentration and storage time on some chemical and sensory quality attributes of uncured, emulsified cooked sausages. *J. Food Sci.* **72**: 324-332.
- Sreekumar, K.P., Rajathi, S., Sheena, G.K., Balaji, S., Jayavardanan, K.K., Mohan, K.S. and Joseph, L. 2007. Haematological and biochemical characteristics of young and adult native ducks of kerala. *J. Vet. Anim. Sci.* **38**: 69-71.
- Sreenivasaiah, P. V., Varadarajulu, P. and Siddiqui, S. M. 1988. Comparison of selected quality characteristics of raw and pre-cooked spent hen breast-meat. *J. Vet. Anim. Sci.* **19**: 8-14.
- Tanganyika, J. and Webb, E.C. 2019. *Sensory characteristics of native Muscovy duck meat in Malawi*. US Space Repository Handle. 2276p.
- Taylor, R. G. 2004. Muscle fibre types and meat quality. In *Encyclopedia of meat sciences*. Oxford, UK: Elsevier. pp. 876-882.
- Wattanachant, S., Benjakul, S. and Ledward, D.A. 2004. Composition, color, and texture of Thai indigenous and broiler chicken muscles. *Poult. Sci.* **83**: 123-128
- Witak, B. 2008. Tissue composition of carcass, meat quality and fatty acid content of ducks of a commercial breeding line at different age. *Arch. Anim. Breed.* **51**: 266-275.

■