REDVET - Revista electrónica de Veterinaria - ISSN 1695-7504
Vol 24, No. 2 (2023)
http://www.veterinaria.org
Article Received: 12 April 2023; Revised: 31 May 2023; Accepted: 20 June 2023

Evaluating the Effects of Forage Quality on Sheep Productivity and Meat Quality

Manashree Avinash Mane[1], Dr. Prasenjit Bhagawati[2], Dr. Naaz Bano[3]

[1]Assistant Professor, Department of Forensic Science, School of Sciences, JAIN (Deemed-to-be University), Karnataka, Bangalore, India, Email Id- m.manashree@jainuniversity.ac.in

[2]Assistant Professor, Department of Agriculture, Assam down town University, Guwahati, Assam, India, Email Id- prasenjit.bhagawati@adtu.in , Orchid Id- 0000-0002-4559-192X

[3]Assistant Professor , School of Agricultural Sciences, Jaipur National University, Jaipur, Rajasthan, India, Email id- naaz.bano@jnujaipur.ac.a

Abstract

In this study, grazing Dorset sheep were used as test subjects to see how a 5-month intense feeding program affected their meat's flavour, fatty acid content, and quality. The Dorset Sheep were separated evenly into 2 categories after being raised in a pasture structure for Five months: the pasture-based grazing fattening (PAS) group and the concentrate-included intense fattening (control) group for five more months. Every animal was slaughtered after the feeding stage to extract subcutaneous fatty tissue from the muscles longissimus dorsi for examination. The findings showed that sheep in the control group had live weight, hot body weight, and dressing percent that were considerably greater than those in the PAS group. Additionally, the control group showed noticeably greater redness (a*), lightness (L*), water-holding capacity levels, and noticeably lower Warner-Bratzler shear force principles, all of which indicated increased meat softness. This shows that the control group had more unsaturated fats, which helped create a healthy fatty acid mix. The smell was stronger in the control group because 4-methyloctanoic acid, 4-ethyloctanoic acid, and 4-methylnonanoic acid levels had risen by two to four times. The pasture-weaned concentrate-included intense feeding strategy resulted in greater meat-producing efficiency among the control group sheep, enhanced meat colour and appearance, and more nutritious fatty acid content. This method offers a viable alternate finishing regimen for lambs and has great promise for the Dorset Sheep meat market.

Keywords: Dorset Sheep, quality meat, grazing methods, flavoured meats

Introduction

To supply the demand for meat products worldwide, sheep farming is essential. Sheep production and meat quality were impacted by several variables, including diet (1). Forages, including pasture and hay, are the staples of a sheep's diet because they offer vital nutrients for development, reproduction, and general well-being. The forage quality is crucial to sheep husbandry since it directly affects the productivity and quality of the meat produced by sheep (2). About the plants that sheep eat, forage quality describes the nutrients it contains and how easily it may be digested. It includes elements including protein content, energy levels, the make-up of the fibre, mineral content, and the existence of secondary chemicals. The efficiency, well-being, and sensory qualities of sheep meat are greatly influenced by these factors and the meats nutritional worth (3). The quality of the fodder is directly related to sheep production. With sufficient nutrients from high-quality forages, ewes can develop,

REDVET - Revista electrónica de Veterinaria - ISSN 1695-7504
Vol 24, No. 2 (2023)
http://www.veterinaria.org
Article Received: 12 April 2023; Revised: 31 May 2023; Accepted: 20 June 2023

reproduce, and produce milk at their best rates. For the survival and growth of lambs, adequate nutrition throughout the gestation and nursing periods is especially crucial.

Market value and customer acceptance are significantly influenced by meat quality (4). The forage's quality significantly impacts the sensory qualities of sheep meat, including Flavor, softness, juiciness, and colour. Optimal forage quality affects intramuscular fat content favourably, which adds to softness and Flavour. Additionally, including bioactive substances in premium forages can improve the nutritional profile of sheep meat, making it more appealing from a health standpoint (5). Farmers, academics, and politicians that work with sheep must comprehend the connection between fodder quality, sheep production, and meat quality (6). Farmers may optimize sheep efficiency, improve meat quality, and implement sustainable production methods by enhancing fodder quality through appropriate management practices such as rotational grazing, fertilization, and selection of suitable forage species. The research (7) investigated the effects of forage quality on sheep productivity and meat quality to better comprehend the nutritional requirements of sheep and establish procedures for management for flocks.

The investigation (8) examined the financial and ecological consequences of 5 sheep breeds based on ewe productivity and feeding expenses. Methods were discovered over a gradient of deteriorating agronomic competence from Ireland to the French Mediterranean rangelands in several biogeographically distinct locations. The quality of the fodder that was available, how much of it was consumed, and how well lambs reared for meat performed were all examined in study (9). There were four pre-grazing canopy heights used in the procedures. 32 sheep were employed to manage pastures using the intermittent stocking approach. By accumulating published measures of grass nutritive value and integrating these data with meteorological, edaphic, and management details, the research (10) evaluated the impacts of growth circumstances on fodder quality. They discovered that the nutritional content of fodder decreased at higher temperatures and rose with the addition of nitrogen fertilizer. A mix of species identification, physiology, and phenology modifications probably caused this.

The research (11) largely concentrated on the significance of issues related to weight gain, slaughtering, and flesh quality regarding nutritional, natural, and genetic factors. The fatty acid composition of subcutaneous fat, essential to sheep's flavour and health advantages, has been the subject of several researches. The study (12) thoroughly analyzed the carcass characteristics, the quality of the sheep meat, and the factors that might influence them. The total amount of carcasses and meat varies greatly and is influenced by various elements, including husbandry practices, breed, slaughter size, and the care given to the animals before slaughter. In investigation (13), lambs given restricted metabolizable energy (ME) intakes were examined for growth rate, serum biochemical indicators, carcass characteristics, meat quality, and nutritional composition to replicate seasonal fluctuations in the pasture ecosystem of China's northwest.

REDVET - Revista electrónica de Veterinaria - ISSN 1695-7504
Vol 24, No. 2 (2023)
http://www.veterinaria.org
Article Received: 12 April 2023; Revised: 31 May 2023; Accepted: 20 June 2023

The research (14) examined the factors that influence each type of lamb with a designated place of origin and protected geographic indication and the factors that contribute to these lambs' unique sensory and chemical characteristics. The sensory quality of items with fresh meat from a certain designation of origin is greatly influenced by Flavour, fragrance, appearance, and colour. The study (15) suggested an innovative LCA technique to supplement the current LCA approach. High geographical and temporal resolution measurements of field data, including fodder quality and the performance of animals, were made and then immediately included in LCA procedures. To offer unbiased data to assess sheep meat's carcass structure and qualitative features, the study (16) examined current technical advancements in non-destructive and non-invasive procedures. The study (17) examined the most current developments in state-of-the-art research on sheep items. Research has greatly benefited farming and processing of sheep meat and food safety.

The investigation (18) assessed the features of native male sheep raised using conventional and organic farming methods. Lambs raised in organic farms had lower daily mean gains than lambs raised in conventional systems. The necessary standards for both traditional and organic methods of production were upheld. To assess the connections among this gene's single-nucleotide polymorphisms, the study (19) looked at a polymorphism in Region 5′ around the gene in colored Polish Merino sheep and factors such as growth, the weight of the body, the carcass, and meat quality. 78 different live and examination features were examined in all. The study (20) evaluated the local supply chain for sheep meat in China and suggested using Petri networks and a UML-based modeling technique to represent the traceability data and procedure. The strategy adhered to the definitions of phase and transitional process of sheep meat.

This research aimed to determine how a foraging Dorset sheep's meat quality, fatty acid composition, flavour, and growth efficiency would change after four months of intense feeding.

The remainder of the paper is divided into subsequent parts. Part 2 contains the method explained. Part 3 includes the results, while Part 4 discusses the conclusions.

Materials and Methods

Animals and the finishing process

At Dorset Sheep, the ewes experience seasonal estrus, and in the middle of March each year, they all give birth to a unique lamb. 44 weaned, nearly 5-month-old “Dorset lambs” were selected for the study from a group of a thousand sheep in the Kawatabi pasture. They were divided into 2 categories with an equal number of 22 lambs in each, tagged, and given the choice of getting either the intensive fattening system (control) or the pasture-based grazing fattening system (PGAS), including nutrients. They were chosen with a median age of 24.7 to 2.5 kilos and average body weight (BOW). The study was conducted at the state-run Honshu Farm in Japan’s Inner Japan (west) Region for 5 months before the animals were slaughtered.

System of grassland-based feeding for fattening: As they got closer to weaning age, all of the sheep in the group were gradually taken from moms over a week. Then, as part of a regular

REDVET - Revista electrónica de Veterinaria - ISSN 1695-7504
Vol 24, No. 2 (2023)
http://www.veterinaria.org
Article Received: 12 April 2023; Revised: 31 May 2023; Accepted: 20 June 2023

daily feeding routine while grazing on pasture in separate flocks, they stayed in the sheepfold at nighttimes. There was water accessible every day from midday till dusk. A system with an intense concentration: The sheep from the control group were brought to the farms in Honshu, weaned at five months old, and then allowed access to grass before being housed in a sheep pen. The entire mixed ration (MR) offered was made up of harvest hay, forage corn, and concentrates in the same ratios as the market for nearby meat sheep (21%:48%:43%). During the closing phase, fresh, pure water was readily available. The chemical structure and amount of fatty acids of the forage grass and MR used in the current investigation were examined after one day of freeze-drying pre-treatment procedures by the Ministry of Agriculture and Rural Affairs' Feed Potency and Safety Supervision, Evaluation, and Assessing Centre (Tokyo, Japan), and the results are shown in Table 1.

Table (1): Combined pasture and overall mixed ration

Items	Pasture	TMR
NDF (%)	54.09	40.56
Crude Protein (%)	11.14	14.95
ADF(%)	28.98	21.35
Ash (%)	5.06	14.52
Ether Extract (%)	1.32	4.35
Moisture (%)	16.62	42.97
GE (MJ/kilo)	14.36	18.45
B12:0 milligram	-	0.3
B13:0 milligram	-	0.3
B14:0 milligram	0.5	0.3
B16:0 milligram	2.5	9.5
B16:0 milligram	-	0.3
B17:0 milligram	-	0.3
B18:0 milligram	0.5	3.3
B18:1n9c milligram	0.9	15.8
B18:2n6c milligram	2.8	26.8
B18:3n3 milligram	5.4	1.6
B20:0 milligram	0.4	0.5
B20:0 milligram	0.3	0.4
B22:0 milligram	0.3	0.5
B22:1 n9 milligram	-	0.3
B23:0 milligram	-	0.3
B24:0 milligram	0.4	0.8

Collection of samples and slaughtering techniques

According to regional finishing traditions, Honshu Farm's norms and regulations for feeding and slaughtering, and most sheep, the slaughter period was ten months for most lambs. After the investigation, every lamb's live weight (LNW) was determined using a heated carcass

REDVET - Revista electrónica de Veterinaria - ISSN 1695-7504
Vol 24, No. 2 (2023)
http://www.veterinaria.org
Article Received: 12 April 2023; Revised: 31 May 2023; Accepted: 20 June 2023

collected after removing the animal's legs, head, trachea, liver, heart, and digestive system. The ratio of hot carcass weight (CW) to lean weight (LNW) was used to compute the dressing percentage (DS). The corpses were then divided longitudinally into 2 equal portions, and the muscles longissimus dorsi (LO) was eliminated on the right side. The carcasses were then transferred to the lab at 5°C within one day to assess the meat's quality features. To evaluate the fatty acid profile and flavour-related substances, fifty grams of the superficial fatty tissue from the twelfth and thirteenth subjects' ribs were collected, packaged in sealed bags, and sent to a laboratory on dry ice for assessment.

Meat quality evaluations

Determined by physical measures: In the same location with the transportable piercing pH meter and acid discharge at 5 degrees Celsius. The pH values of the flesh materials were originally recorded as pH1 and, one day afterward, indicated as pH26. The CIE L*, a*, and b* colorimetric systems were used to determine the color of the longissimus lumborum muscles within a single day of the animal's death. "L* (lightness)" defines the relationship between reflecting and absorbent light without mentioning a unique wavelength. "Positive a* indicates red", whereas "negative a* indicates green". A negative one indicates blue, whereas "positive b*" denotes yellow. To gauge the amount of cooked flesh (cooking loss), a hundred grams of meat (M1) was put in a plastic bag and heated in a tub of water at 73 degree Celsius. When the instance reached 71degree Celsius, it was removed to cool at ambient temperature, wiped dry, and weighed again (M2) before being cut into 219 cm pieces. The percentage of cooked flesh was calculated as $M2\,/M1 \times 100\%$.

The meat portions were shaved with the direction of the fibers in the muscle perpendicular using a softness analyzer using WBSF tools. The surface analyzer's crosshead distance and speed settings were 24 mm and 62 mm/min, respectively. The water holding capacity (WC) of an object cut to a measurement of 1 cm and gathered using a circular sampling with a length of 2.452 cm was determined by computing the mill loss and weighing the sample as M3. There was filter paper with two layers around the circular object, then filter paper with 16 layers on top and edge of everything. After five minutes of being subjected to a pressure of 34 kilos on the meat press platforms, the product was immediately weighed as M4. As $\frac{M3-M4}{M3} \times\ 100\%$, the WC was calculated. Moisture level (ML) and intramuscular fat (IM) were evaluated with "Soxhlet" procedures, as was previously described. In an aluminum jar, well-defined 6 to 8-gram samples of crushed meat were inserted, combined with ethanol and sandy sea soil, and dried for four at 104°C in a desiccators to reach room temperature before being weighed (M5). The ML was computed as $\frac{M5-M6}{M5} \times 100\%$. The Soxhlet equipment was then used to extract the dried materials with petrol ether for six hours at 62°C. Following the solvent's evaporation, At 100°C for sixty minutes, the flask holding the fat was evaporated; desiccators were chilled to room temperature before being measured (M8). $Fat\ = \frac{M8-\ M7}{M5} \times 100\%$ was used to determine the amount of intramuscular fat.

REDVET - Revista electrónica de Veterinaria - ISSN 1695-7504
Vol 24, No. 2 (2023)
http://www.veterinaria.org
Article Received: 12 April 2023; Revised: 31 May 2023; Accepted: 20 June 2023

Fatty acids' composition was discovered using solid-phase microextraction (SME) techniques and gas chromatography-mass spectrometry (G-MS). Simply said, a portion of the fatty samples was removed from the -85 degree Celsius freezer and put into a 20 ml glass container with three milliliters of acetylcholine-methanol and two milliliters of n-hexane. The closed vial was warmed in a water bath at 82 degrees Celsius after being shaken every 25 minutes for two hours. Add 6 ml of 6% Na2CO3 (m/v) and shake until homogeneous after the mixture has cooled to ambient temperature. After cooling, insoluble materials were taken out. The mix was spun at 3 kilos for five mins. The organic material was separated, and the remaining aqueous material was again extracted using 3 ml "n-hexane". The 2 organic phases were mixed to maintain a consistent volume of 6 ml. Then, the solution was filtered through an organic phase filtration membrane with a 0.23 m pore size and kept at -19°C for analysis.

Fatty acid compounds were isolated on "fused silica DB-5MS capillary column, and helium was utilized as the carrier gas at a rate of flow of 1.4 ml per minute to accomplish the solution preparation using a 7965A GC with 7000B Triple Quadruple MS GC/MS." The split was adjusted to 30:2 ratios with a 10-minute solvent delay. The injection mode was employed. The G oven's temperature was originally set at 62 degrees Celsius and maintained there for 2 minutes before being increased to 265 degrees Celsius at a rate of 4 degrees Celsius per minute and finally to 305 degrees Celsius at a rate of 20 degrees Celsius per minute and maintained there for five minutes. With the quadruple temperature set at 155°C, the higher sensitivity electron ionization (EIZ) ion source was operating at 235 degrees Celsius. The operational parameters for the mass spectrometer (MSM) were adjusted to positive EIZ mode (EIZ +), utilizing automated gain control and electron energy of 68 eV. Both the complete scan and unique-ion tracking modes of the MSM were employed. The Agilent mass hunter workstation software was used to gather the data. A mass spectra library with a similarity index of 810 or higher was used to compare volatile substances' mass spectra and retention times to those corresponding to conventional compounds to identify them.

Compounds assay for Flavor related: Once the taste-related compounds "4-methyl phenol and 3-methylindole" were discovered, the previously described method was slightly altered. The fatty tissue contents were portioned, sealed, and put into 20 mL headspace vials that were threaded through a SME extractor tip. The collected instances were immediately injected using extraction needle and then heated at 65°C to 95°C for 20–50 minutes in a water bath before being analyzed by "G–MSM." Helium was used as the carrier gas at a steady flow rate of two milliliters per minute without buffer delay, and the DB-WAX chromatographic column was used for division. The initial setting of the oven was first held at fifty degrees Celsius for 1 minute, then increased to 115°C at a rate of 12°C per minute, increased to 235°C at a rate of 5°C per minute, and finally kept constant for a total of five minutes. The MSM was set up with those above operational and data collection parameters in view.

Statistic evaluation

Excel Pro 2019 was used for the statistical analysis, and p0.05 was used to establish the significance of the effects. Using SPSS 22.0 and Past V5.11 to perform data standardization

REDVET - Revista electrónica de Veterinaria - ISSN 1695-7504
Vol 24, No. 2 (2023)
http://www.veterinaria.org
Article Received: 12 April 2023; Revised: 31 May 2023; Accepted: 20 June 2023

and computation, accordingly, to assess the characteristics of good eating and show the connection between factors and samples, the "principal component analysis (PCA)" was used.

Results and discussion

Characteristics of physical quality of meat and slaughter

Table 2 shows how the finishing affected the characteristics of lambs that would be used for slaughter. When compared to the pasture finishing method, the indoor fattening system considerably outperformed it in terms of CW and LNW within identical time frames. As a result, the control group's lambs had a high DS and less fluctuation in their BW. When contrasting the PAS and control groups' actual quality of meat measurements, the "lightness (L*), redness (a*)," and with the possible exception of mill loss (ML), WC were all noticeably greater in the trial group compared to the control group, WBSF, and pH1 and pH24, which were all within the usual range of principles. The values of other variables, such as "yellowness (b*)," dropping loss, ML, and Similar amounts of cooked flesh, were consumed by both groups. Despite a small increase in the IM in CONTROL lambs, it did not reach a statistically significant amount. The meat appeared darker red, brilliant, and tender overall when viewed in terms of the physical metrics, and the indoor finishing substantially enhanced the meat's quality.

Table 2

Table (2): Measures of the meat's quality and slaughtering characteristics

Characteristics	PAS		CON		Significance Level
	Mean	SD	Mean	SD	
LW(kilo)	35.41	6.09	38.13	5.59	*
WBSF (N)	73.45	25.86	56.56	21.86	*
DP (%)	45.38	4.78	52.07	2.58	***
CMP (%)	86.27	4.03	85.59	3.5	NS
a*	19.87	2.78	24.58	2.59	***
b*	7.91	2.43	7.36	0.46	NS
ML(%)	32.3	5.19	29.8	3.19	*
L*	37.09	2.36	40.26	0.76	***
pH_{24}	6.89	0.09	6.79	0.19	*
MC (%)	74.98	3.18	75.48	25.18	NS
DL (%)	3.28	0.59	2.36	0.36	NS
IMF (%)	3.48	0.79	4.63	0.85	NS
pH_1	7.75	0.18	7.38	0.19	***
HCW (Kilo)	16.72	4.45	20.46	2.83	***
WHC (%)	59.53	5.63	62.59	5.32	*

REDVET - Revista electrónica de Veterinaria - ISSN 1695-7504
Vol 24, No. 2 (2023)
http://www.veterinaria.org
Article Received: 12 April 2023; Revised: 31 May 2023; Accepted: 20 June 2023

Profile of fatty acids in subcutaneous fat

The approach used in the research allowed for the identification of eight different major fatty acid types in the sheep's subcutaneous adipose tissue. According to Table 3, these were linoleic acid, myristic acid, palmitic acid, stearic acid, palmitoleic acid, oleic acid, and palmitoleic acid. Fatty acid composition of various manufacturing is shows in Figure 1. The control group, compared to the PAS category, had higher amounts of unsaturated fatty acids, demonstrated by the significantly reduced MA content and substantially lower levels of PA. The control group also had about the same amount of saturated fatty acids (SF), although this difference was not statistically significant. The rising USF/SF ratio demonstrates that the unsaturated content of the subcutaneous fat in the control group increased, which contrasted with the control group's considerably greater content of OA and LA.

Table 3

Table (3): Fatty acid composition of various manufacturing

Characteristics	PAS		CON		Significance Level
	Mean	SD	Mean	SD	
MA (B14:0, %)	8.07	3.50	5.83	2.24	**
PA (B16:0, %)	28.56	3.56	23.68	2.86	***
SA (B18:0, %)	19.86	3.84	21.68	3.42	NS
POA (B14:1, %)	2.98	0.86	2.68	0.41	NS
OA (B18:1, %)	32.65	3.68	38.92	3.35	***
LA (B18:2, %)	3.00	0.49	3.53	0.56	***
SFA (%)	59.05	5.09	58.08	4.56	NS
USFA (%)	38.83	4.92	43.49	4.57	*
USFA/SFA	0.70		0.76		

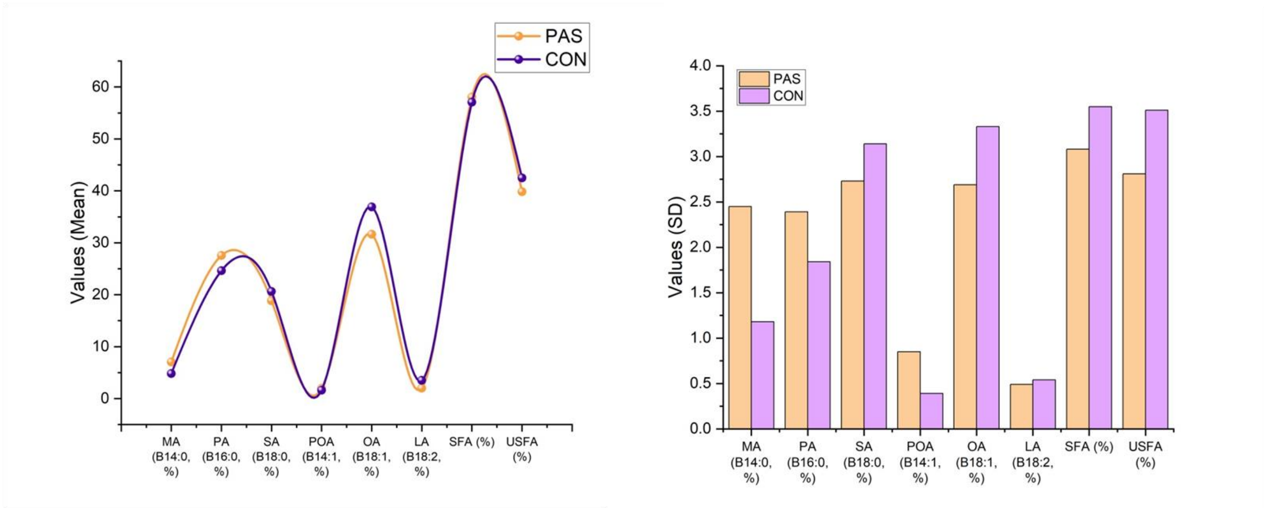

Figure (1): Fatty acid composition of various manufacturing

REDVET - Revista electrónica de Veterinaria - ISSN 1695-7504
Vol 24, No. 2 (2023)
http://www.veterinaria.org
Article Received: 12 April 2023; Revised: 31 May 2023; Accepted: 20 June 2023

Flavoured substances in subcutaneous fat

The proportion of flavour chemicals contained in the perceptions of different manufacturing techniques varied significantly depending on the fatten technique, as seen in Table 4. Despite the control group having a substantially lower MP level, the amount of branched-fatty acids (BCFs) was significantly higher. Despite a considerable increase in MI in the control group as well, it did not reach a meaningful level. Figure 2 shows the Substances of flavour.

Table (4): Substances of the flavour

Characteristics	PAS		CON		Significance Level
	Mean	SD	Mean	SD	
MOA (μg/g)	5.50	7.98	20.70	15.94	***
EOA (μg/g)	9.24	8.07	18.48	13.14	**
MNA (μg/g)	0	0	21.89	23.59	*
MP	554.97	534.46	135.58	112.45	**
MI	186.34	77.52	314.48	155.02	NS

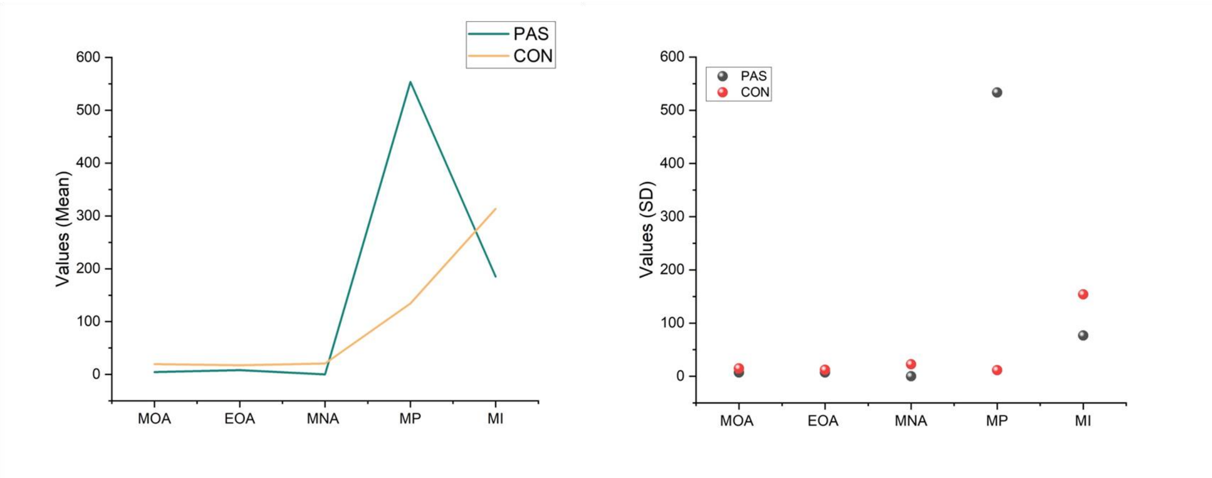

Figure (2): Substances of the flavour

The eating quality's primary aspect evaluation

The results of PCA using data from the fatty acid profile, flavour-related chemicals, and physical meat quality characteristics are shown in Figure 3. The first two primary elements, PC1 and PC2, contributed 23.71% and 14.22%, respectively, to the first two principal components' overall contribution of 35.35%. Compared to the other observed indications, PC1 was most positively impacted by MI, MOA, OA, and WC, while MA and ML most adversely impacted PC1. IM and yellowness (b*) had a stronger favourable impact on PC2, whereas pH24, WC, ML, and WBSF had a more detrimental impact.

REDVET - Revista electrónica de Veterinaria - ISSN 1695-7504
Vol 24, No. 2 (2023)
http://www.veterinaria.org
Article Received: 12 April 2023; Revised: 31 May 2023; Accepted: 20 June 2023

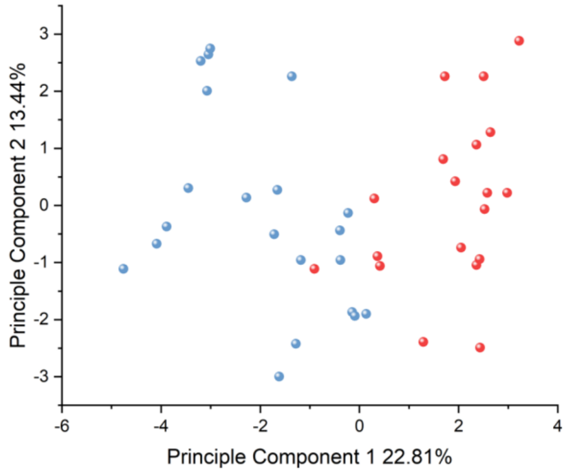

Figure (3): Result of PCA

Conclusion

This research used sheep from 2 grazing regimens grassland feeding with concentrates—for a thorough contrast, particularly in flavor character with G-MS rather than experienced sensitive panel. The findings showed alterations in the forage and rearing conditions, which greatly influenced the fat content, physical parameters of the flesh, and growth efficiency. Utilizing TMR's fattening approach after being weaned on pasture resulted in more productive meat, had a redder and brighter color, was tastier, and had an improved fatty acid profile for the well-being of humans. Although the concentrated inclusion feed scheme greatly increased the main BCFA content in Dorset Sheep, it was still lower than most sheep varieties. It did not materially impair the breed's good traits. In summary, it was clear that the grassland-weaned demanding fattening method (control group) provides an effective alternative plan for lamb finishing production, having a wide potential for growth and application in the Dorset Sheep meat industry, making use of both grassland grazing and constrained intense feeding arrangements.

References

[1] Martínez-de-Quel, Ó., Suárez-Iglesias, D., López-Flores, M. and Pérez, C.A., 2021. Physical activity, dietary habits, and sleep quality before and during COVID-19 lockdown: A longitudinal study. Appetite, 158, p.105019.

[2] Sejian, V., Bhatta, R., Gaughan, J., Malik, P.K., Naqvi, S.M.K. and Lal, R., 2017. Adapting sheep production to climate change. Sheep production adapting to climate change, pp.1-29.

[3] Gkarane, V., Brunton, N.P., Allen, P., Gravador, R.S., Claffey, N.A., Diskin, M.G., Fahey, A.G., Farmer, L.J., Moloney, A.P., Alcalde, M.J. and Murphy, P., 2019. Effect of finishing diet and duration on lamb meat's sensory quality and volatile profile. Food Research International, 115, pp.54-64.

[4] Bernabéu, R., Rabadán, A., El Orche, N.E. and Díaz, M., 2018. Influence of quality labels on the formation of preferences of lamb meat consumers. A Spanish case study. Meat Science, 135, pp.129-133.

[5] Pethick, D.W., Hocquette, J.F., Scollan, N.D. and Dunshea, F.R., 2021. Improving the nutritional, sensory, and market value of meat products from sheep and cattle. Animal, 15, p.100356.

[6] Bay-Larsen, I., Risvoll, C., Vestrum, I. and Bjørkhaug, H., 2018. Local protein sources in animal feed-Perceptions among arctic sheep farmers. Journal of Rural Studies, 59, pp.98-110.

[7] de Otálora, X.D., Epelde, L., Arranz, J., Garbisu, C., Ruiz, R. and Mandaluniz, N., 2021. Regenerative rotational grazing management of dairy sheep increases springtime grass production and topsoil carbon storage. Ecological Indicators, 125, p.107484.

[8] Benoit, M., Sabatier, R., Lasseur, J., Creighton, P. and Dumont, B., 2019. Optimizing the economic and environmental performances of sheep-meat farms does not fully fit with the meat industry's demands. Agronomy for sustainable development, 39(4), p.40.

[9] Emerenciano Neto, J.V., Difante, G.S., Lana, Â., Medeiros, H.R., Aguiar, E.M., Montagner, D.B. and Souza, J.S., 2018. Forage quality and performance of sheep in Massai grass pastures managed at pre-grazing canopy heights. South African Journal of Animal Science, 48(6), pp.1073-1081.

[10] Lee, M.A., Davis, A.P., Chagunda, M.G. and Manning, P., 2017. Forage quality declines with rising temperatures, with implications for livestock production and methane emissions. Biogeosciences, 14(6), pp.1403-1417.

[11] Knapik, J., Ropka-Molik, K. and Pieszka, M., 2017. Genetic and nutritional factors determining the production and quality of sheep meat-a review. Annals of animal science, 17(1), p.23.

[12] Corazzin, M., Del Bianco, S., Bovolenta, S. and Piasentier, E., 2019. Carcass characteristics and meat quality of sheep and goats. More than beef, pork and chicken–the production, processing, and quality traits of other sources of meat for the human diet, pp.119-165.

[13] Song, S., Wu, J., Zhao, S., Casper, D.P., Zhang, L., He, B., Lang, X., Wang, C., Gong, X., Wang, F. and Liu, L., 2018. The effect of periodic energy restriction on growth performance, serum biochemical indices, and meat quality in sheep. Journal of Animal Science, 96(10), pp.4251-4263.

[14] Erasmus, S.W., Muller, M. and Hoffman, L.C., 2017. Authentic sheep meat in the European Union: Factors influencing and validating its unique meat quality. Journal of the Science of Food and Agriculture, 97(7), pp.1979-1996.

[15] McAuliffe, G.A., Takahashi, T., Orr, R.J., Harris, P. and Lee, M.R.F., 2018. Distributions of emissions intensity for individual beef cattle reared on pasture-based production systems. Journal of cleaner production, 171, pp.1672-1680.

[16] Silva, S., Guedes, C., Rodrigues, S. and Teixeira, A., 2020. Non-destructive imaging and spectroscopic techniques for assessment of carcass and meat quality in sheep and goats: A review. Foods, 9(8), p.1074.

[17] Teixeira, A., Silva, S. and Rodrigues, S., 2019. Advances in sheep and goat meat products research. In Advances in Food and Nutrition Research (Vol. 87, pp. 305-370). Academic Press.

[18] Islam, S.M.A., Farzana, F., Murshed, H.M. and Rahman, S.M.E., 2019. Study on meat quality of native sheep raised in organic and conventional production systems. Journal of Meat Science and Technology| January-March, 7(01), pp.01-07.

[19] Grochowska, E., Borys, B., Janiszewski, P., Knapik, J. and Mroczkowski, S., 2017. Effect of the IGF-I gene polymorphism on growth, body size, carcass and meat quality traits in Coloured Polish Merino sheep. Archives animal breeding, 60(2), pp.161-173.

[20] Yan, C., Huanhuan, F., Ablikim, B., Zheng, G., Xiaoshuan, Z. and Jun, L., 2018. Traceability information modeling and system implementation in Chinese domestic sheep meat supply chains. Journal of Food Process Engineering, 41(7), p.e12864.