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Lamb or hogget meat – A different sensory profile? Extending the fresh meat season in Norway

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ABSTRACT

This study compared the meat sensory profile of lambs (5 months old) and hoggets (17 months old) from two sheep breeds, Norwegian White Sheep (NWS) and Norwegian Spel (NS). The loin (left and right) samples (*M longissimus thoracis et lumborum*) from 50 carcasses were analysed for 23 sensory attributes by a trained sensory panel using quantitative descriptive analysis evaluated on an unstructured line scale from 1 (lowest intensity) to 9 (highest intensity). There was an effect ($P < 0.05$) of animal age on the attributes: odour (fried roasted, sheep and intensity), flavour (fried roasted, gamey, sheep, rancid and liver), hardness, tenderness, fatness, and coarse fibre structural unit. The loin muscles of lambs were scored significantly lower compared to that from the hoggets in all the sensory attributes except rancid odour, flavour, and juiciness. Sheep odour, hardness, and coarse fibre intensity differed between breeds ($P < 0.05$) – the NWS breed obtained a higher score than the NS breed. Meat from lambs of both breeds and the hogget NS breed was similar in tenderness while that from the NWS hoggets was scored lower by the panel. For the attribute hardness, lambs and hoggets were similar within each breed, except the NS hoggets were similar to NWS lambs. There was an interaction between animal age and breed ($P < 0.05$) for the fried roasted and gamey odour. The results indicate that animal age has a lower impact on eating quality for the NS breed than for the NWS breed. In the Norwegian scenario, the NS hoggets appear more suitable for supplying fresh out-of-season meat. Results should be confirmed with a larger sample size of both breeds.

1. Introduction

Norwegian sheep are bred in late autumn with lambing in the spring season, followed by summer range grazing and slaughter in autumn. This strong seasonality has resulted in a short period (in autumn) in which fresh lamb meat is available for the consumer (Bhatti et al., 2019). Consequently, large quantities of lamb carcasses are frozen, with an associated reduction in eating quality of the meat (Muela et al., 2016). Increasing the availability of fresh meat out-of-season may increase the overall annual consumption and reduce the need for storage facilities and extra workforce during the peak slaughtering season. Any modification in the sheep farming system needs to account for the feeding requirements during intensive winter feeding and extensive summer grazing. One way to increase the out-of-season fresh meat supply is to retain lambs until they reach hogget (12 months or more of age) in the spring. Another option is to hold chilled vacuum-packed meat for up to 10 weeks to supply fresh meat during the December to January period. Therefore, there is still a lack of fresh meat from February-July which needs to be filled.

It has been shown that for a number of different "genotypes" sheep meat quality is affected by animal age (Purchas, 2007; Hopkins and Mortimer, 2014). This is manifested as increased toughness, particularly in the hind leg cuts and darker meat (Hopkins et al., 2007). With increasing age of the animal, the muscle collagen becomes less soluble due to increased cross-linkages between collagen molecules resulting in an increased shear force (Young et al., 1993). Wiese et al. (2005) reported that the sensory quality of hogget is similar to that of lamb meat and suggested the possibility of including of a new "yearling" sheep

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category in the Australian meat classification system, with particular focus on the loin cuts. The increase in intramuscular fat found in older animals (Wiese et al., 2005; Hopkins et al., 2006) may compensate for any increased toughness in hoggets.

There are two distinct sheep breeds in Norway: a composite crossbred sheep, the Norwegian White Sheep (NWS), and the Norwegian Spel (NS) - a smaller breed, that anecdotally prefers grazing on high areas and is more adapted to local conditions (Steinheim et al., 2008; Bhatti et al., 2019). The NS breed seems more adapted to the natural environment compared to the NWS due to a smaller body stature and lower weight and is possibly more suited to grazing the higher mountain pastures producing a leaner carcass with comparatively less subcutaneous fat.

Generally, Norwegian sheep carcasses are classified into lamb (< 1-year-old), hogget (1–2.5 years old) and sheep (> 2.5-year-old) based on animal age at slaughter. Lamb meat is sold at a much higher market price than meat from hoggets and older sheep (Norway Today, 2017). The need to feed hoggets and older sheep for longer periods makes it uneconomical for farmers to raise them as a mainstream product. Meat consumers prefer lamb meat over sheep meat due to its recognised better quality in terms of tenderness and colour (Fogarty et al., 1995; Hopkins and Mortimer, 2014), which affects the market value for older sheep meat. Scientific evidence demonstrating selected portions of hogget meat to be equal to lamb meat in terms of sensory traits, could be used in a marketing strategy to raise the profile of this product and increase sales to justify the retention of animals to yearlings to increase out of season fresh meat supply in Norway.

In order to promote NS hogget as an option for out-of-season fresh meat production, it is vital to know the sensory meat quality. To our knowledge, no research has been conducted to establish and compare the meat sensory profile of hogget with the lamb meat of the NS breed. The aim of this experiment was, therefore, to test the effect of sheep age on meat sensory traits and further compare the sensory profile of meat from lambs (5 months old) and hogget (17 months old) of the two main Norwegian sheep breeds, the crossbred NWS and modern NS breed.

2. Materials and methods

2.1. Study animals experimental design and slaughter

Fifty animals were reared at the experimental sheep farm of Baroniet Rosendal (59° 59′ 22.74″ N, 6° 1′ 44.94″ E) located in Kvinnherad in Hordaland county, Norway. One NWS ram and 3 NS rams sired the 50 animals used in the study. These study animals were selected based on age (5 and 17 months for lambs and hoggets respectively) and breed (NWS and NS). The animals (n = 50) were divided into four groups: NWS hogget (n = 16) and NWS lambs (n = 9); NS hogget (n = 16) and NS lambs (n = 9).

During summer months, all animals had free access to unimproved mountain pastures in south-western Norway ranging from 50 to 900 m above sea level with the NS-breed preferring higher and steeper pastures. Before slaughter, the animals grazed on the same cultivated pasture for four weeks before being transported to a commercial abattoir (80 km away). At arrival, the animals were held in lairage overnight with free access to water and slaughtered as one group using a head-only stunning method as a routine procedure at the abattoir in a randomised order.

Due to the high biodiversity on the natural pastures sampling and estimation of rangeland feed quality was not feasible. The cultivated pasture harvested as silage for winter feed had an average dry matter content (DM) of 20.7 %, crude protein (CP) 11.8 %, neutral detergent fibre (NDF) 50.6 % and the organic matter digestibility (OMD) was 72 %.

2.2. Carcass sampling

The carcasses were processed at a commercial abattoir without using electrical stimulation. The hot carcasses were placed on separate hooks, weighed and graded for body conformation and external fat classification using a 15-point scale of the European Union EUROP classification system (Johansen et al., 2006). The carcasses were chilled (3–4 °C) overnight, and the 24 h post-mortem temperature (average temperature ± 4.2 °C) of 10 carcasses selected randomly was recorded by inserting a temperature probe into the 9th rib region of the *longissimus thoracis* (LT) muscle (Okeudo and Moss, 2005).

After overnight chilling, the *m. longissimus thoracis et lumborum* (LL) from both sides of the carcass were removed between the $12^{th}/13^{th}$ ribs. The left loin and right loin muscles (n = 100) were wrapped and vacuum-packed as per routine procedures of vacuum packaging at the slaughterhouse and transported to Nofima AS (Ås, Norway). At Nofima, the samples were stored at 4 °C for seven days, and the pH (average 5.6) of the left and right LL was measured using a meat pH meter (meat electrode Mettler and Microprocessor pH Meter, Portamess® 752, SOLIDS, Switzerland) prior to the sensory assessment. The pH meter was calibrated as per manufacturer recommendations before use.

2.3. Sensory analysis

To objectively describe the perception of the meat samples, a trained panel of 11 sensory assessors performed a Quantitative Descriptive Analysis QDA, ISO 13,299:2016 E of the samples Lawless and Heymann, 2010). Assessors were selected and trained following recommendations in ISO 8586-1:2012(E). In the present experiment, assessors were trained and calibrated on two samples from each breed and age category, for the purpose of agreeing on the variation in different sensory attribute intensities. A standard serving procedure, as described by Lawless and Heymann (2010), was used. Water was served between each test for rinsing the palate. The left loin (L) and right loin (R) muscles were randomised and cut into pieces of 1.5 cm each, heated at 70 °C in a combi-oven (Electrolux Air-o-steam, Model AOS061EANQ) for 30 min and served from a hot plate at 65 °C to the sensory panel. A continuous, non-structural scale from 1 (lowest intensity) to 9 (highest intensity) was used for evaluation following NS-ISO 5492:1999 (ISO, 1992). Four sensory modalities (odour, flavour, taste, texture) were evaluated including 23 sensory attributes (Table 1).

The samples within the experimental categories: NWS hogget, NWS lamb, NS hogget and NS lamb, were served randomly to each assessor. The samples were coded with three-digit numbers and served to the assessors in blind trials randomised according to sample, assessor and replicate in a total of 13 sessions conducted over three days. The left

Table 1
The sensory modalities evaluated and the sensory attributes tested by the sensory panel.

Sensory modalities	Attributes
Odour attribute	Fried roasted, intensity of odour, sour, wet wool, sheep, gamey, rancid and liver
Flavour attribute	Fried roasted, intensity of flavour, wet wool, sheep, gamey, rancid and liver
Taste attribute	Sour, sweet and bitter
Texture attribute	Hardness*, juiciness, tenderness, fatness and coarse fibre structural unit

* Hardness: the force required to bite completely through the sample when placed between molar teeth (Lawless and Heymann, 2010).

and right loin muscles were evaluated indistinctly by the assessors. Each assessor evaluated the samples at their own leisure on a computerised system for the direct recording of data (EyeQuestion® web application software, version 4.11.33 (Build 1123), Netherlands).

2.4. Statistical analysis

Based on the 11 (10 on day 2) assessors' scores, data were analysed one trait at a time using the fixed general linear model:

$$y = mean + age + breed + age \times breed + e$$

where y is one of the traits assessed (averaged over the assessors) for each carcass, *age* is either lamb or hogget, *breed* is either NWS or NS, and *age* × *breed* is the interaction of the two, all taken as fixed effects, and e is the residual.

The panel used to assess the samples were trained in such assessments. Data were analysed with the R-package lm(), significance levels of the fixed effects found (with anova() function), and model-based means (using lsmean() package in R) for the fixed effects estimated with standard errors, based on the above model.

The data were also analysed with lmer() using a mixed model, with the random terms *individual carcass* and *assessors* added to the model; this yielded similar results.

A multivariate analysis was conducted with Principal Component Analysis using RStudio package PCA() for averages over the assessors, to show the main correlations of traits, to be able to relate them to individual carcasses, and to the effects of the model. The Tukey method was used for comparing the four sensory modalities (odour, flavour, taste, texture) of 23 sensory attributes. The $P < 0.05$ was considered to be significant in the statistical analyses.

3. Results

The NS lambs and hoggets were lighter at slaughter yielding lower hot carcass weights (Table 2). The live weight and hot carcass weight difference between hoggets and lambs of the NS breed was 11.0 kg and 3.0 kg respectively, and for the NWS breed was 29.1 kg and 12.3 kg respectively (Table 2). The average fatness score of NWS hoggets was higher than the NWS lambs; however, it was slightly lower for NS hoggets compared with NS lambs. In comparison, the NS lambs were fatter than NSW lambs.

3.1. Sensory analysis

Results from the QDA showed that component 1 and 2 from the PCA plot explained 59 % of the total variability of the data (Fig. 1). PCA components 1, 2, and 3 altogether explained 70 % of the variability in the data. The data points representing lambs (NWS/NS breed in turquoise/lavender colour) are situated in the lower left side, and data points representing hoggets (NWS/NS breed in green/salmon colour) tend to be in the upper right side (Fig. 1). Moreover, the NS lambs (lavender data points) are closer to the hogget NS (salmon data points) compared to the hogget NWS (green data points). Generally, the data points representing hogget NS exhibit more spread but are closer to the data points of NS lambs. The distribution of the attributes is presented as a variables factor map of the sensory attributes in Fig. 2. The fried roasted odour and flavour are correlated while the sheep flavour, sheep odour, gamey odour and hardness are related and appear in the same dimension in the two first dimensions of the PCA.

Table 2
Least square mean (SD) live weight, slaughter weight, European Union EUROP carcass classification conformation score and fatness score of lamb and hogget of NWS and NS breeds. Different letters [a,b] in the same row indicate significant statistical differences (P < 0.05, Tukey's test).

	NWS		NS	
Age-group	Lamb	Hogget	Lamb	Hogget
Live weight, kg	45.2[a] ± 6.1	74.3[b] ± 8.1	45.6[a] ± 3.1	56.6[c] ± 6.2
Carcass weight, kg	17.8[a] ± 3.0	30.1[b] ± 3.9	17.0[a] ± 0.9	20.0[a] ± 2.8
EUROP conformation[a]	7.0[a] ± 1.7	8.3[b] ± 0.9	6.9[a] ± 1.0	6.4[a] ± 0.6
EUROP fatness[b]	5.4[a] ± 1.6	6.8[ab] ± 1.4	7.1[b] ± 0.8	6.7[ab] ± 1.0

[a] Scale 1–15 (15 = best conformation).
[b] Scale 1–15 (15 = fattest).

3.1.1. Age (lamb/hogget), breed (NWS/NS) and age × breed interaction effects

Significant interactions for age × breed were found for odour attributes fried roasted and gamey, and for flavour gamey (Table 3). There appeared to be less variability in meat sensory attribute scores for the NS breed relative to the NWS breed. Differences ($P < 0.05$) between samples from hogget and lamb, regardless of breed, were found for several attributes (Table 4) where lamb compared to hogget had lower intensity in both odour (fried roasted, sheep odour, intensity) and flavour attributes (fried roasted, gamey, sheep flavour, rancid, liver flavour). Differences were also observed for the texture attributes, in which lamb was evaluated to be softer and more tender.

For the breeds (NWS and NS), differences ($P < 0.05$) were found for the sensory attributes: sheep odour, hardness and coarse fibre structural unit, where NWS recorded significantly higher scores than the NS breed. Fried roasted odour changed significantly for NWS, while for the NS breed age did not cause any significant change (Table 4). Sheep odour scores were affected by both breed and age. Furthermore, hardness and coarse structural fibre unit scores were also significantly influenced by breed.

4. Discussion

In the current study, the sensory evaluation of the meat samples was undertaken using a well-trained sensory panel based on Quantitative Descriptive Analysis (QDA). Trained sensory panels are used in order to get accurate and repeatable objective data due to the panellists' uniqueness in sensitivity, interest, motivation and ability to judge the sensory differences in the given product (Lawless and Heymann, 2010; Liu and Zhang, 2020).

The sensory analysis showed that sensory profile of NS lamb meat was similar to NS hogget meat in our experiment while the sensory profile of NWS lamb meat was not similar to NWS hogget meat. This breed difference may stem from the fact that NWS hoggets achieved higher liveweights and higher subcutaneous fat levels compared to NS lambs and hoggets. The NS-breed was less influenced by animal age than the NWS-breed (Table 3). The sensory profile and carcass weight of lambs and hoggets of the NS breed were closer to each other compared to the lambs and hoggets of the NWS breed. The collagen concentration is reported to be a better indicator of sensory tenderness than collagen solubility as the solubility of collagen decreases with increase in animal age (Young and Braggins, 1993). The NS hogget had grown at a slower rate than NWS hogget, and this might affect the concentration of the collagen in the muscle and the tenderness of the meat. The slow growth of NS hoggets with lower collagen concentration compared to the NWS hoggets might be the reason for NS hoggets obtaining a lower hardness score from the panel compared with the NWS hogget. The slower growth of the NS hoggets may be due to the breed or the treatment before this experiment was initiated.

Since consumer demand for specific meat cuts is shifting to smaller sized animals because of smaller household sizes (Fowler et al., 2018), the smaller carcass weight of the NS appears to make this breed more suitable for targeting a hogget product for the winter period. The findings of this study indicate that consumer liking will not be affected since there was no major difference in flavour attributes, especially for the NS-breed. Meat from NS-hoggetsis more likely to be accepted by

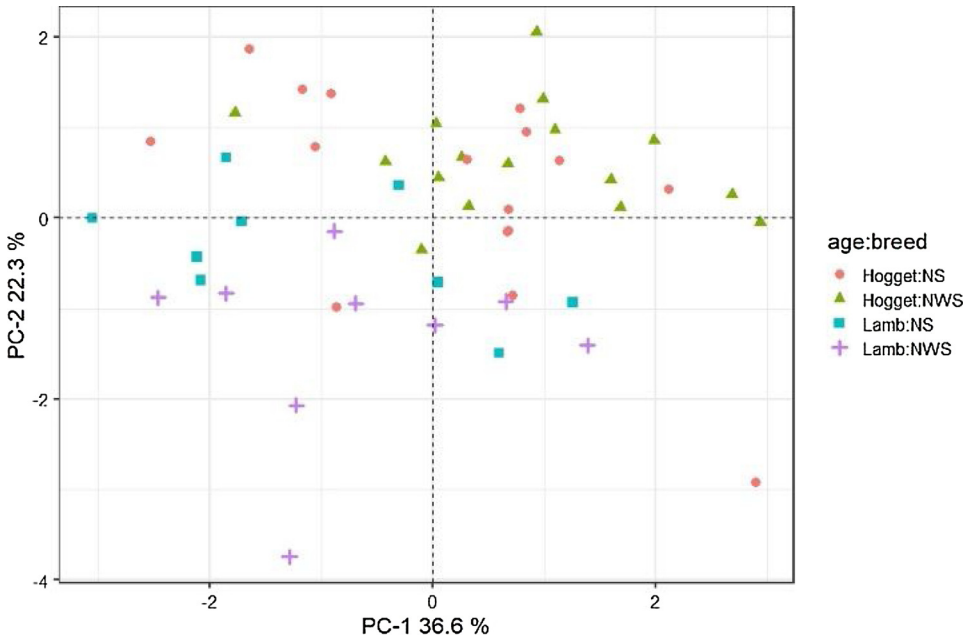

Fig. 1. Principal Component Analysis (PCA) averages per individual for the significant sensory attributes (PC-1 and PC-2).

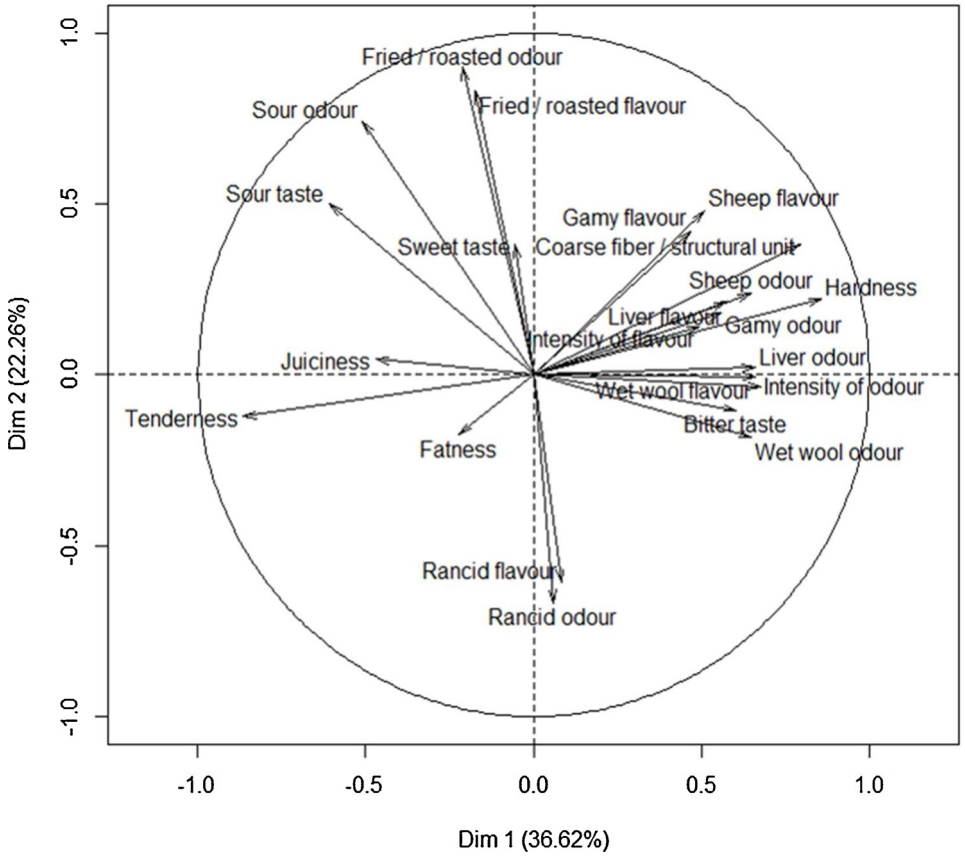

Fig. 2. Biplot for the significant sensory attributes showing the sensory dimensions (Dim) 1 & 2 from the Principal Component Analysis (PCA).

consumers than meat from NWS hoggets due to less increase in undesirable flavours. The findings of this study are also similar to the results of Wiese et al. (2005). They concluded that increasing animal age did not affect the liking of flavour by consumers. In their study the meat cuts used were stripped carefully of subcutaneous and intermuscular fat. This is likely to lessen differences since the fat component is the one that contributes in a major way to the development of flavours.

Current industry practice promotes the production of lamb meat rather than hogget and older sheep of any breed by paying farmers a higher price/kg for lamb meat. The results of the current study can be used to support a marketing strategy for NS hoggets on the basis of providing an equivalent eating experience to lamb, but at a lower price. However, we found significant differences in lamb and hogget meat

Table 3
The significance (P values) of effects of age, breed, and age × breed on the odour, flavour, and texture attributes based on the analysis of the average scores from the trained sensory panel tested samples from m. longissimus thoracis et lumborum (LL). Only traits with some significant effects ($P < 0.05$) included.

	Age	Breed	Age × Breed
Odour			
Fried roasted	0.001	0.06	0.01
Gamey	0.057	0.73	0.01
Sheep	< 0.001	0.009	0.79
Intensity	0.03	0.06	0.13
Rancid	0.07	0.60	0.33
Flavour			
Fried roasted	0.002	0.11	0.30
Gamey	< 0.001	0.60	0.05
Sheep	< 0.001	0.16	0.35
Intensity	0.06	0.31	0.31
Rancid	0.006	0.88	0.83
Liver	0.01	0.81	0.55
Texture			
Hardness	< 0.001	0.01	0.28
Tenderness	< 0.001	0.18	0.68
Fatness	0.037	0.16	0.94
Juiciness	0.098	0.67	0.58
Coarse fibre structural unit	< 0.001	0.03	0.36

Table 4
The effects of breed (NWS vs NS) and age (lamb vs hogget) on sensory attribute scores (odour, flavour, and texture) (lsmean and SE) describing the quality of meat obtained by a trained taste panel offered meat samples from *m. longissimus thoracis et lumborum* (LL). A score of 1 indicates low/no intensity and 9 indicates high intensity for each parameter following NS-ISO 5492:1999 (ISO, 1992). Different letters ^{a,b,c} in the same row indicate significant statistical differences ($P < 0.05$, Tukey's test).

	NWS				NS			
	Lamb	Hogget			Lamb		Hogget	
Attribute	Mean	S.E	Mean	S.E	Mean	S.E	Mean	S.E
Odour								
Fried roasted	2.76^{b}	0.24	4.02^{a}	0.18	3.83^{a}	0.24	4.01^{a}	0.18
Gamey	2.57^{b}	0.15	3.15^{a}	0.11	3.03^{ab}	0.15	2.96^{ab}	0.11
Sheep	3.86^{ab}	0.13	4.25^{b}	0.10	3.53^{a}	0.13	3.97^{b}	0.10
Intensity	5.20^{b}	0.14	5.66^{ab}	0.10	5.66^{ab}	0.14	5.75^{a}	0.10
Sour	3.20^{a}	0.19	3.50^{a}	0.14	3.39^{a}	0.19	3.42^{a}	0.14
Wet wool	3.60^{a}	0.17	3.57^{a}	0.12	3.37^{a}	0.17	3.50^{a}	0.12
Rancid	1.72^{a}	0.12	1.42^{a}	0.09	1.64^{a}	0.12	1.55^{a}	0.09
Liver	2.54^{a}	0.16	2.79^{a}	0.12	2.65^{a}	0.16	2.61^{a}	0.12
Flavour								
Fried roasted	2.50^{b}	0.15	3.07^{a}	0.11	2.89^{ab}	0.15	3.18^{a}	0.11
Flavor intensity	5.44^{a}	0.09	5.67^{a}	0.07	5.62^{a}	0.09	5.69^{a}	0.07
Wet wool	3.53^{a}	0.18	3.64^{a}	0.13	3.23^{a}	0.18	3.51^{a}	0.13
Sheep	3.79^{a}	0.16	4.53^{b}	0.12	3.77^{a}	0.16	4.23^{ab}	0.12
Gamey	2.58^{b}	0.12	3.16^{a}	0.09	2.90^{ab}	0.12	3.06^{a}	0.09
Rancid	1.82^{a}	0.10	1.55^{a}	0.08	1.79^{a}	0.10	1.55^{a}	0.08
Liver	2.63^{a}	0.17	3.11^{a}	0.13	2.71^{a}	0.17	3.01^{a}	0.13
Texture								
Hardness	4.46^{a}	0.17	5.35^{b}	0.13	4.32^{b}	0.17	4.89^{ab}	0.13
Tenderness	5.22^{a}	0.26	4.22^{b}	0.19	5.39^{a}	0.26	4.58^{ab}	0.19
Juiciness	5.30^{a}	0.17	5.12^{a}	0.13	5.47^{a}	0.17	5.13^{a}	0.13
Coarse fiber	4.62^{a}	0.12	5.37^{b}	0.09	4.53^{a}	0.12	5.07^{b}	0.09
Fatness	3.44^{a}	0.07	3.30^{a}	0.05	3.35^{a}	0.07	3.23^{a}	0.05
Sour taste	3.70^{a}	0.20	3.73^{a}	0.15	3.76^{a}	0.20	3.64^{a}	0.15
Sweet taste	3.42^{a}	0.06	3.52^{a}	0.04	3.47^{a}	0.06	3.44^{a}	0.04
Bitter taste	3.98^{a}	0.07	4.04^{a}	0.06	3.96^{a}	0.07	4.10^{a}	0.06

from the NWS breed (Table 4 and 5) that indicates the NWS lambs should be slaughtered in peak slaughtering season and NWS hogget should be used for breeding rather than meat production. If farmers are offered a better price for hogget meat, it will be a motivation to rear hoggets for supplying fresh meat during the off-season, provided that the additional costs for feeding are reflected in the sales price.

Pethick et al. (2005) reported no difference in the objective measurement of the tenderness and the consumer tenderness on 12 months old lambs and 22 months old yearlings of Merino breeds. Therefore, a further study at large scale and under controlled conditions in terms of feeding, should be conducted. Thus, testing of the NS breed will also be important to understand the production and economic viability of this breed to produce more out-of-season fresh meat. Since this study was limited to the measurement of sensory meat quality of both ages and breeds in the LL muscle; a further study involving consumer acceptance tests to verify the sensory quality of hogget meat based on different muscles would be essential to develop either the NS or NWS breeds for out of season production. Results of the current study could be helpful in marketing meat to consumers in terms of sensory quality from hoggets of the NS breeds.

5. Conclusion

Based on the study results, the sensory profile of loin meat from lamb and hoggets of the NS breed is similar, and this could be used to promote the production of fresh meat from hoggets during the off-season. NS hoggets have a lighter carcass, an additional benefit for selling NS hogget meat to avoid undesirable flavours associated with the higher subcutaneous fats in heavier carcasses. The NS breed may be perceived as a more native breed that is more acclimatised to grazing mountain pastures, and it shows potential as a species for the conservation of the Norwegian rangeland. Our results, however, should be verified with a larger sample of lambs representing a wider genetic base.

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Declaration of Competing Interest

The authors declare that they have no conflict of interest.

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