

# Growth performance, carcass characteristics and meat quality of Northern Finncattle steers compared to Holstein steers offered grass silage-grain-based ration

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## Abstract

**Background:** Finnish beef production is largely based on dairy breeds. Eastern Finncattle, Western Finncattle, and Northern Finncattle (NFC) are native breeds, whereas Holstein (HO) and Nordic Red are the most important commercial dairy breeds. The NFC has been the closest to extinction among Finnish native cattle breeds. The objective of the experiment was to provide data on meat quality of NFC compared to HO. To our knowledge no previously published scientific data about the meat quality traits of NFC is available.

**Results:** The targeted slaughter age was 600 days for both NFC and HO. The carcass gain of the HO steers was 60% higher compared to NFC steers. No breed differences in dressing proportion, carcass conformation, or carcass fat score were observed. Breed had no effect on the pH, color, drip loss, chemical composition, shear force value, or sensory tenderness of the *longissimus lumborum* muscle. However, beef flavor of the NFC steers was evaluated 7% better compared to the HO steers. In addition, the *longissimus lumborum* muscle of the NFC steers tended to be juicier than that of the HO steers.

**Conclusions:** Only little variability in meat quality traits was observed between the breeds. However, NFC requires a longer growing period than HO when targeting the same carcass weight. To promote the use of the NFC in beef production, it is necessary to find other than economic production efficiency features, which would provide added value for premium meat quality to compensate the lower production efficiency.

## KEYWORDS

beef production, beef quality, eating quality, gain, native breed

## INTRODUCTION

Beef production in Finland is mostly based on dairy breeds. On average 80% of the produced beef is of dairy breed origin and only 20% is either from pure beef breeds or crossbred beef animals.<sup>1</sup> Finnish native dairy breeds, Eastern Finncattle (EFC), Western Finncattle (WFC), and Northern Finncattle (NFC), are named based on their geographic breeding areas but are nowadays bred all over country.

Holstein (HO) and Nordic Red (NR), however, are the most important commercial dairy breeds in Finland.<sup>2</sup> All three Finncattle breeds were on the verge of extinction in the 1990s. Kantanen and Ojala<sup>3</sup> reported that in 1970 there were 307,600 Finncattle cows, in 1980 their number was dropped to 42,800, and in 1991 down to 7900. The NFC has been the closest to extinction among Finnish native cattle breeds. The population of the breed was only 99 heads in 1988 and 50 heads in 1993.<sup>4</sup> However, due to systematic work and funding for

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cryopreservation of semen and embryos the number of individuals in the native breeds is slowly increasing.<sup>5</sup> The number of purebred NFC increased between 2004 and 2017 from 317 to 848 heads.<sup>6</sup> In 2022, about 889 purebred NFC cows existed in Finland.<sup>7</sup>

Oldenbroek<sup>8</sup> stated that ex situ conservation of native breeds can technically be organized in gene banks. Nevertheless, in situ conservation of breeds, or farming that takes place in their native territories, where they have adapted to the environment and where their development can continue, is preferred.<sup>8</sup> Meat production is a small but increasing sector in farming of native breeds such as NFC. The challenge with native cattle breeds is their low production level, which consequently is not profitable for farmers.<sup>9</sup> For example, when comparing beef production traits of NR, HO, NFC, EFC, and WFC bulls, Huuskonen<sup>2</sup> observed clearly lower carcass gain of the native breeds compared to the commercial NR and HO breeds. In addition, carcasses of the native breeds had poorer conformation compared to NR and HO.<sup>2</sup> In many countries, the production of native cattle breeds is supported by agri-environmental schemes.<sup>9</sup> However, according to Hiemstra et al.,<sup>10</sup> this is not an economically sustainable option in the long term. Therefore, milk and meat production chains for native cattle breeds should be developed so, that they become profitable alternatives on market terms. The NFC is well adapted to arctic climate conditions, but its resilience, well-developed grazing traits, and other good features are still underutilized compared to the opportunities it offers.

Recently, Sunds et al.<sup>11</sup> observed that milk of WFC has a suitable quality for special food ingredients such as infant formula or healthy ingredients. To support similar development possibilities for beef from native breeds, research of meat quality traits is required. Carcass and meat quality of European native cattle breeds have been documented to some extent.<sup>12,13</sup> Also, growth performance, carcass characteristics and valuable cutting yields of Nordic native cattle breeds have been characterized.<sup>2,14</sup> Therkildsen et al.<sup>14</sup> concluded that all Finnish and most of the Norwegian and Swedish native breeds had lower carcass gain and carcass weight compared to the commercial dairy breeds in the same category and country. Furthermore, they suggested that the carcass traits of the native breeds indicate that they have some advantages in an extensive production system based on forage and marginal grasslands. However, to the best of our knowledge, there is no scientifically published information available about the meat quality traits of NFC compared to commercial dairy breeds. Therefore, the objective of the present experiment was to compare the carcass and meat quality parameters of purebred NFC and HO breeds.

## MATERIALS AND METHODS

### Animals, housing and feeding

The experiment was conducted in a private farm in Tervola, Finland (66°14'N, 24°96'E) and comprised in total of 12 NFC and 11 HO steers. Natural Resources Institute Finland (Luke) and the University of Lapland were responsible for the experiment. Animals were purchased from local dairy farms at the age of 29 ± 16.1 days. They were castrated at their

**TABLE 1** Chemical compositions and feeding values of grass silage and crimped barley grain and calculated chemical compositions and feeding values of total mixed ration (TMR) used in the experiment.

	Grass silage	Barley grain	TMR
Number of samples	8	4	
Dry matter (DM), g/kg feed	323	571	391
Crude protein, g/kg DM	145	114	133
Neutral detergent fiber, g/kg DM	576	163	411
Metabolizable energy, MJ/kg DM	10.5	12.9	11.5
Metabolizable protein, g/kg DM	85	96	89
Protein balance in the rumen, g/kg DM	21	-27	2
Digestible organic matter in DM, g/kg DM	655		
Silage DM intake index	110		
Fermentation quality of grass silage			
pH	4.34		
Volatile fatty acids, g/kg DM	23		
Lactic + formic acid, g/kg DM	34		
Water soluble carbohydrates, g/kg DM	42		
NH <sub>4</sub> N in total N, g/kg	63		

growing and finishing farm at the age of 43 ± 14.4 days for the ease of handling of cattle. During the pre-experimental period, the animals were fed milk replacer (until the age of 65 days), grass silage, commercial concentrate, crimped grain, and mineral-vitamin mixture. During the pre-experimental period, the animals were housed in an insulated barn in pens providing approximately 3 m<sup>2</sup> per steer.

During the experiment, the animals were managed according to Finnish legislation regarding the use of animals in scientific experimentation. This study design was reviewed and approved by Animal Welfare body (Government decree 564/2013 22§) of Natural Resources Institute Finland. Project authorization was not needed as the experiment did not cause the animals a level of pain, suffering, distress, or lasting harm equivalent to, or higher than, that caused by the introduction of a needle (2010/63/EU). At the start of the feeding experiment, NFC and HO steers were 124 ± 17.1 and 126 ± 18.6 days old and weighed 106 ± 17.2 and 132 ± 13.2 kg, respectively. During the experimental period, the animals were housed in an uninsulated barn in six pens, four animals per pen so that the animals from the same breed were penned together. At the start of the experiment, the space allowance per steer was 3.1 m<sup>2</sup> and it increased as the animals grew, being 6.0 m<sup>2</sup> per steer at the end of the experiment. The steers were offered total mixed ration (TMR) ad libitum during the whole experimental period. The TMR used included, on dry matter (DM) basis, grass silage (600 g/kg), crimped barley grain (380 g/kg), and mineral-vitamin mixture (20 g/kg). The steers had free access to water throughout the experiment.

Feed samples for chemical analyses were collected throughout the experiment, the silage samples on average once a month and the grain samples on average every 3 months. All samples were analyzed for DM, crude protein (CP), and neutral detergent fiber (NDF), and silage samples also for digestible organic matter (DOM) in DM (DOMD, D value). The DM values were determined by oven drying and silage DM was corrected for loss of volatiles.<sup>15</sup> The CP, NDF, and D values were determined by near-infrared spectroscopy as described by Nousiainen et al.<sup>16</sup> The silage was analyzed also for fermentation quality (pH, water-soluble carbohydrates, lactic and formic acids, volatile fatty acids, and ammonia N content of N) by electrometric titration as described by Moisio and Heikonen.<sup>17</sup> The metabolizable energy concentrations of feeds were calculated as described by Huuskonen et al.<sup>18</sup> The protein value of the feeds is expressed as amino acids absorbed from the small intestine (metabolizable protein) and the protein balance value in the rumen according to Luke.<sup>19</sup> The relative intake potential of silage DM (SDMI index) was calculated as described by Huhtanen et al.<sup>20</sup>

The grass silage used in the present experiment had a relatively good nutritional quality as indicated by the D value as well as the CP content (Table 1). The fermentation characteristic of the silage was good as indicated by the pH value and the concentration of ammonia N and total acids. Barley grain had typical chemical composition and feed values, corresponding to the average values in the Finnish Feed Tables.<sup>19</sup> The energy and protein values of the TMR used corresponded to Finnish feeding recommendations for growing cattle.<sup>19</sup>

## Growth, slaughtering and carcass traits

The targeted slaughter age was 600 days for both breeds, and the slaughter age was used as the endpoint of the study. The steers were weighed at the beginning and at the end of the experiment. The live weight (LW) gain (LWG) was calculated as the difference between the means of the initial and final LW divided by the number of growing days. The estimated rate of carcass gain was calculated as the difference between the final carcass weight and the carcass weight at the beginning of the experiment divided by the number of growing days. The carcass weight at the start of the experiment was assumed to be  $0.49 \times$  initial LW based on earlier studies.<sup>21</sup>

The steers were slaughtered in two batches with captive bolt stunning followed by exsanguination at Leivejoen Liha facility (owned by Vainion Teurastamo Ltd.). The carcasses were chilled at  $+1^{\circ}\text{C}$  for 24 h prior to meat sampling. The slaughter and dressing procedures were in accordance with the EU specifications. The transportation time from the farm to the slaughterhouse was approximately 1 h and the animals were allowed overnight rest before slaughter. After slaughter, the carcasses were weighed hot. The cold carcass weight was estimated as 0.98 of the hot carcass weight.<sup>22</sup> Dressing proportion was calculated from the ratio of cold carcass weight to final LW. The carcasses were graded for conformation and fat score in accordance with the EU beef carcass classification scheme on a continuous 15-point scale.<sup>23</sup>

## Meat quality traits

After the slaughter, sampling for pH 20 min post-mortem measurements, weighing and classification, and overnight chilling at  $+1^{\circ}\text{C}$ , the carcasses were commercially cut. For the meat analyses, the *longissimus lumborum* muscle (LL) from the right side of each carcass was cut between the 7th and 8th ribs and the junction of the *gluteus medius* muscle. Three samples were taken in the following order, starting from the caudal part of LL: (1) a sample of approximately 10 cm in length for the determination of ultimate pH, color, drip loss, marbling, and chemical composition (moisture, protein, and fat content), (2) a sample of approximately 15 cm in length for Warner-Bratzler shear force (WBSF) measurements, and (3) a sample of approximately 12–15 cm in length for sensory evaluation (tenderness, flavor, juiciness).

Meat samples were placed in their own bags and vacuum packed (KT 300 II, Koneteollisuus Ltd., Klaukkala, Finland) and stored at 0 to  $+4^{\circ}\text{C}$  until the first sample was analyzed at 48 h after the slaughter. The other two samples were aged at 0 to  $+1^{\circ}\text{C}$  for 21 days and stored frozen at  $-20^{\circ}\text{C}$  until the shear force and sensory analyses took place.

Measurement of pH 20 min post mortem was done using the iodoacetate method, which allows the actual pH recordings of the sample later at laboratory instead of the carcass processing line. Approximately 20 min after exsanguination, according to the method described by Jeacocke,<sup>24</sup> a 0.3–0.5 g sample of LL was mixed and ground with spatula in 5 mL sodium iodoacetate solution in a test tube. The mixture was stored for 48 h at  $+4$  to  $+6^{\circ}\text{C}$  until pH 20 min post-mortem recordings were done with a pH meter Mettler Toledo 345 (Mettler Toledo, Canada) and an electrode Mettler Toledo 51343054 InLab<sup>®</sup> Routine Pro pH Electrode (Mettler Toledo, Canada).

For measuring the ultimate pH (pH 48 h post mortem) of LL, samples were ground through a 4 mm disc screen using a meat mincer Bosch ProPower 2200 W (type CNFW8, Bosch, China). The ultimate pH was measured from the 1:1 mixture of minced meat and distilled water with a pH meter Mettler Toledo 345 (Mettler Toledo, Canada) and an electrode Mettler Toledo 51343054 InLab<sup>®</sup> Routine Pro pH Electrode (Mettler Toledo, Canada) according to Korkeala et al.<sup>25</sup> at 48 h after the slaughter.

The color of LL was measured with a Minolta colorimeter (Konica Minolta spectrophotometer CM-5, Konica Minolta INC, Osaka, Japan) on a 3-mm-diameter measuring area. Before the measurements, the spectrophotometer was zero-calibrated with a solid black cylinder and with a white tile (CM-A210). Additionally, the target color, light red-dish tile nr 19 according to Luke own numbering was set. The measurements were done with a CIE standard D65 light source and a  $10^{\circ}$  observer viewing angle and the readings were displayed in  $L^*a^*b^*$  ( $L^*$  lightness; luminance from 0 to 100,  $a^*$  redness; green to red, and  $b^*$  (yellowness; blue to yellow)). A steak slice of approximately 2.0 cm thickness was kept in daylight with the fresh cut surface upward and the color was measured for each sample after a blooming time of approximately 5 min. A mean value of four replicates of each sample was calculated and used for statistical analyses as a meat color value

for individual animals. Marbling score was visually assessed using a six-point scale (0 = no marbling/internal fat; 5 = very marbled/internal fat).

Drip loss was measured according to the method of Honikel<sup>26</sup> by suspending a meat sample weighing about 80–100 g in a plastic bag for 4 days at 0 to +1°C temperature. Drip loss, the amount of liquid leaking out of the meat, was calculated as the difference between the initial weight of the meat sample and the weight after suspension. The result was expressed as a drip loss percentage of the initial weight.

The frozen (–20°C) and thawed (overnight at +4°C) LL sample was trimmed from external fat and connective tissue prior to chemical analyses. Before the proximate composition analyses, the samples were ground through a 4 mm disc screen using a meat mincer Bosch Pro-Power 2200 W (type CNFW8, Bosch, China). The moisture content of the samples was determined by freeze-drying (Christ gamma 2–20, Martin Christ Gefriertrocknungsanlagen GmbH, Osterode am Harz, Germany). Nitrogen concentration was determined according to an accredited method based on AOAC 984.13 (Association of Official Analytical Chemists, USA) using Cu as a digestion catalyst and a Foss Kjeltec 2400 Analyzer Unit (Foss Tecator AB, Höganäs, Sweden). CP concentration was calculated as  $N \times 6.25$ . Ether extract was determined according to AACC method 30–25 using Soxtec<sup>TM</sup> 8000 extraction unit and Hydrotec<sup>TM</sup> hydrolysis unit, (FOSS Analytical, Denmark).

For the shear force measurements, the aged sample of LL was cut parallel to the myofibres into five pieces of 6 cm in length and 2 cm × 2 cm cross-sectional area and put into plastic bags, 2 or 3 pieces in the same bag. The samples were heated in a water bath at 85°C to an internal temperature of 70°C. After that, the samples were chilled at +4°C overnight. Shear force was measured using a Lloyd Testing Instrument (Lloyd 1000 R, Lloyd Instruments PLC, Segensworth East Fareham, Hampshire, England). The sample was cut with a Warner-Bratzler cutting blade (1-mm-thick) across the muscle fiber direction. The maximum shear force required to cut each piece was measured four times for each of the five samples, resulting in 20 measurements per one sample. The mean value of 20 measurements was used for statistical analyses to describe the WBSF for the individual animal.

Luke is committed to the Finnish National Board on Research Integrity TENK guidelines<sup>27</sup> which covers the non-medical and non-clinical research on humans (Finnish Medical Research Act 488/1999).<sup>28</sup> In the present study, the beef sensory analysis experimental design did not include elements that according to the TENK guidelines<sup>27</sup> would have required ethical pre-evaluation of the experimental design. Additionally, sensory evaluation of beef in the present study was based on voluntary participation of the panelists to the beef sensory evaluation sessions. For the sensory evaluation, surface fat was removed from the aged, frozen (–20°C), and thawed (overnight at +4°C) sample and the sample was cut into 1.5-cm-thick slices. The slices were heated up to internal temperature of 60°C in a rolling grill (Palux Rotimat, Germany). Heated samples were immediately served and assessed by seven to nine trained sensory panelists. Two 1.5 × 1.5 cm pieces from each sample was served per panelist. The

panelists evaluated independently the samples for tenderness, juiciness, and flavor using a seven-point scale (1 = very tough/very dry/very non-beef-like and 7 = very tender/very juicy/very beef-like).

## Statistical analysis

The results are shown as least squares mean. The normality of residuals was checked using graphical methods: box plots and scatter plots of residuals and fitted values. For parameters that were measured several times per sample (color, WBSF, and sensory analysis) the average value was used for the statistics (one single value per animal). The data were subjected to analysis of variance using the SAS GLM procedure (version 9.4, SAS Institute Inc., Cary, NC, USA). The statistical model used was

$$y_{ijkl} = \mu + \delta_j + \alpha_i + \theta_{ijl} + \beta x_{ijk} + e_{ijkl},$$

where  $\mu$  is the intercept and  $e_{ijkl}$  is the residual error term associated with  $k$ th animal.  $\alpha_i$  is the effect of  $i$ th breed (NFC, HO), while  $\delta_j$  is the effect of the slaughtering batch ( $j = 1, 2$ ) and  $\theta_{ijl}$  is the effect of the pen. The effect of the pen was used as an error term when differences between breeds were compared because treatments were allocated to animals penned together. Initial LW was used as a covariate ( $\beta x_{ijk}$ ) in the model for gain and carcass traits parameters.

## RESULTS AND DISCUSSION

The average final LW and carcass weight at the age of 600 days were 46% and 43% higher, respectively, in the HO steers compared to the NFC steers ( $p < 0.001$ ) (Table 2) due to superior growth performance of the HO steers. The LWG and carcass gain of the HO steers were 65 and 60% higher, respectively than those of the NFC steers ( $p < 0.001$ ). The difference in growth performance of the breeds observed in the present study was in line with the results based on Finnish national slaughter data reported by Huuskonen,<sup>2</sup> where the carcass gain of HO breed bulls (542 g/day) was 41% higher compared to NFC bulls (385 g/day). In addition, Huuskonen<sup>2</sup> observed that HO bulls had 39% heavier carcasses compared to NFC (333 vs. 238 kg). In that report, the difference in slaughter age between HO and NFC bulls was 14 days (587 vs. 573, respectively). Recently, Therkildsen et al.<sup>14</sup> also observed that NFC animals had lower carcass gain and carcass weight compared to HO. The poorer growth rate in the present data compared to the data reported by Huuskonen<sup>2</sup> is at least partially explained by the fact that the animals were steers, while the animals in Huuskonen's<sup>2</sup> data were bulls. The growth rate of steers is typically slower compared to bulls.<sup>29,30</sup>

No differences were observed in dressing proportion, carcass conformation score, or carcass fat score between the studied breeds (Table 2). This is consistent with the data reported by Therkildsen et al.,<sup>14</sup> who observed no differences in carcass conformation score when comparing NFC and HO breed animals. However, these results

**TABLE 2** Effects of breed on growth performance and carcass characteristics of Northern Fincattle (NFC) and Holstein (HO) steers.

	Breed		SEM <sup>a</sup>	p-value	NFC		HO	
	NFC	HO			Min	Max	Min	Max
Number of animals	12	11						
Slaughter age, day	601	604	4.8	0.716	576	618	577	631
Final live weight, kg	407	596	16.9	<0.001	294	477	538	660
Live weight gain, g/day	606	1000	35.5	<0.001	422	797	843	1098
Carcass gain, g/day	308	491	19.6	<0.001	190	412	436	559
Carcass weight, kg	204	292	9.3	<0.001	136	247	261	332
Dressing proportion, %	49.9	48.8	0.51	0.166	44.5	52.0	47.8	51.5
Carcass conformation, EUROP (1–15)	3.8	4.2	0.44	0.528	2.0	5.0	2.0	6.0
Carcass fat score, EUROP (1–15)	7.9	6.1	0.87	0.211	4.0	12.0	4.0	9.0

<sup>a</sup>Standard error of the mean.**TABLE 3** Effects of breed on meat quality of *musculus longissimus lumborum* of Northern Fincattle (NFC) and Holstein (HO) steers.

	Breed		SEM <sup>a</sup>	p-value	NFC		HO	
	NFC	HO			Min	Max	Min	Max
Number of animals	12	11						
pH								
20 min postmortem	6.67	6.64	0.052	0.705	6.38	6.86	6.25	6.90
48 h postmortem	5.42	5.46	0.017	0.109	5.32	5.52	5.35	5.53
Color								
L* (lightness)	26.7	27.2	0.61	0.557	24.3	31.2	24.7	31.4
a* (redness)	10.6	11.1	0.38	0.338	9.6	12.8	8.1	14.2
b* (yellowness)	9.6	10.5	0.41	0.097	8.0	11.6	7.4	13.6
Drip loss, %	4.4	4.0	0.49	0.543	1.5	8.4	1.8	5.0
Chemical composition, g/kg								
Moisture	713	721	5.2	0.281	684	737	693	743
Protein	209	210	2.3	0.759	200	224	194	225
Fat	175	161	16.8	0.547	95	272	65	256
Marbling score <sup>b</sup>	2.17	2.18	0.274	0.969	1.00	3.00	1.00	4.00
Shear force, N/4 cm <sup>2</sup>	91	93	6.6	0.824	63	137	71	126
Sensory analysis								
Tenderness <sup>c</sup>	5.2	4.5	0.34	0.149	3.3	6.6	2.6	6.3
Juiciness <sup>d</sup>	5.1	4.6	0.19	0.084	4.6	5.9	3.7	5.7
Flavour <sup>e</sup>	5.4	5.0	0.12	0.045	4.7	6.1	4.7	5.6

<sup>a</sup>Standard error of the mean.<sup>b</sup>Marbling score: scale from 0 to 5 (0 = devoid, 5 = abundant).<sup>c</sup>Scale 1–7; 1 = extremely tough, 7 = extremely tender.<sup>d</sup>Scale 1–7; 1 = extremely dry, 7 = extremely juicy.<sup>e</sup>Scale 1–7; 1 = very poor, 7 = very good.

differ from the findings by Huuskonen,<sup>2</sup> in which NFC bulls had poorer conformed carcasses compared to HO bulls. Regarding the carcass fat score, the present results differed from the previous results of both Huuskonen<sup>2</sup> and Therkildsen et al.,<sup>14</sup> who observed that NFC animals were fatter than HO animals. When comparing the present carcass fat scores of the steers with the carcass fat scores of HO bulls

from our previous feeding experiments, (4.7 and 4.8 in References [18,31]) the steers of both breeds were clearly fatter than the HO bulls in the previous feeding experiments, on average. The difference in the carcass fat score between the present experiment and previous feeding experiments is largely explained by the fact that steers typically have fatter carcasses compared to bulls.<sup>29,30,32</sup>

Breed had no effect on the pH 20 min or pH 48 h post-mortem of the LL muscle (Table 3). The pH 48 h post-mortem, the ultimate pH, was 5.44, on average, which is generally considered a good pH for beef. For example, Węglarz<sup>33</sup> stated that high-quality beef has ultimate pH at the range of 5.4–5.6. At pH over 5.8 decreased meat delicacy as well as lowered possibility of maintaining good quality during cooling is observed. In addition, high ultimate pH can be characterized by gummy structure, increased water-holding capacity, and decreased specific taste.<sup>34,35</sup>

There were no differences in lightness ( $L^*$  value) or redness ( $a^*$  value) of LL muscle between the studied breeds (Table 3). However, the muscle yellowness ( $b^*$  value) tended to be 10% higher in the HO steers compared to the NFC steers ( $p < 0.1$ ). To our knowledge, there is no scientific published information available comparing the meat quality traits of NFC and HO breeds. However, differences in meat color can occur between cattle breeds. For example, Aass and Vangen<sup>36</sup> and Pesonen et al.<sup>37</sup> reported that meat from Charolais breed or Charolais crosses was lighter compared to meat from Hereford breed or Hereford crosses. Since the meat lightness was less than 30 in both breeds in the present experiment with the color measurement scale 0 = black and 100 = white, the meat can be interpreted as having been dark. The lightness of the beef is usually more than 30, but less than 40, depending on factors such as breed and feeding.<sup>38–40</sup>

Breed had no effects on the drip loss or chemical composition of the LL muscle (Table 3). Especially regarding drip loss and meat fat content, there was a large variation among the individual animals. The protein content of the meat in the present experiment was at the same level with many previous studies with growing cattle.<sup>37,41–44</sup> In general, the meat fat content was high in both breeds. Savell and Cross<sup>45</sup> stated that in terms of acceptable consumer satisfaction, the amount of intramuscular fat is 30–40 g/kg. This was clearly exceeded by both breeds in the present study. The high meat fat content in the present study is probably partly explained by the fact that the animals were steers. Bulls have typically had clearly lower fat content in previous experiments with similar silage-based feeding as in the present study.<sup>37,42,43</sup>

There were no differences in the marbling score between the studied breeds (Table 3). The reason for this could be that there were no breed differences either in the carcass fat score or the meat fat content. Marbling of the meat is fat accumulated in perimysium (the intramuscular connective tissue layer between the muscle fiber bundles), which reduces mechanical strength of it and improves meat tenderness.<sup>46,47</sup> It is often associated to the fatness of the animal.<sup>48</sup> The marbling score of fatter animals is usually higher than that of leaner ones. Regarding beef eating quality, marbling is a desirable feature for example among British and French but lean beef is preferred by Spanish and Australian consumers.<sup>49</sup>

Breed had no effects on the shear force value or sensory tenderness of the LL muscle (Table 3). In contrast, beef flavor of the NFC steers was 7% better compared to the HO steers ( $p < 0.05$ ). In addition, the LL muscle of the NFC steers tended to be juicier than that of the HO steers ( $p < 0.10$ ). This outcome is promising from the point of

view of the NFC breed, but further research with larger data would still be needed to verify the results. In addition, the results should also be verified for bulls and heifers. Although, Conanec et al.<sup>13</sup> concluded that there is little variability in sensory quality of beef from European cattle breed bulls despite the differences in carcass, muscle, and beef characteristics the present results show that some differences exist, which in this case could perhaps be used to promote the use of the NFC in beef production.

## CONCLUSIONS

Overall, the present data showed that the growth performance of the HO steers was clearly higher compared to the NFC steers but there were no differences in carcass conformation score or carcass fat score between the breeds. Only little variability in meat quality traits were observed between NFC and HO steers. However, it was noteworthy that the present study indicated that beef flavor of NFC would be better compared to HO. Since NFC animals cannot compete with dominant breeds in growth performance and carcass weights the strengths of the NFC breed must be sought in other attributes, like beef quality and flavor. To promote the use of the NFC breed in beef production, it is necessary to look for features that are not directly related to production efficiency, but from which added value and a better price could be obtained for beef to compensate for weaker production characteristics. In addition to beef quality, for example, the breed's uniqueness, storytelling, and the image of northern Finland could be used, and the breed and beef obtained from it could be branded as a special product. Based on the results of this experiment, further research is needed to provide additional information on the meat quality characteristics of NFC to assess whether meat quality characteristics could promote the use of NFC in beef production. In addition, research is also needed on the meat quality characteristics of NFC bulls and heifers.

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## CONFLICT OF INTEREST STATEMENT

The authors declare no conflict of interest.

## DATA AVAILABILITY STATEMENT

The data that support the findings of this study are available from the corresponding author upon reasonable request.

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