AGRICULTURE AND FOOD

Consumer driven innovation towards improved beef and lamb meat quality

Partnership project summary

RISE Report : 2021:37

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Photos and figures

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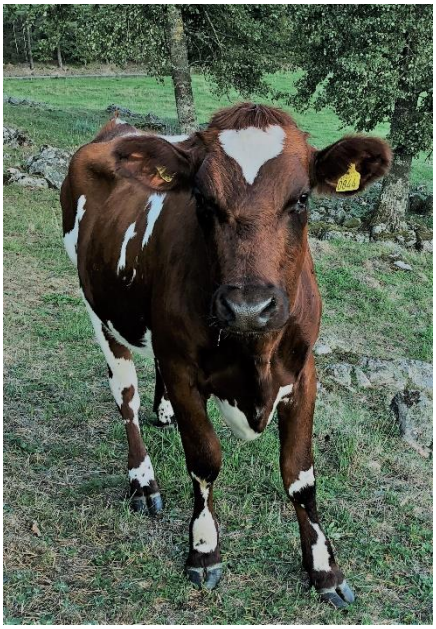
Content

Preface

The priority of this project has been innovation and how new methods and techniques can stimulate new investments and collaboration between companies, research and innovation teams with focus on new products and services.

The objective was to identify techniques and methods that provides better conditions for beef and lamb meat producers and food process industries. By focusing on the customers' demand for higher eating and ethic quality, the result from this project is expected to increase competitiveness, both on a national and an international market.

Partners in this project have been aiming at finding solutions for an environmentally and economically sustainable beef and lamb meat production in Sweden and Denmark.



The intention of the project has been to meet the ongoing debate on meat consumption and its impact on the environment and health. When produced in a way that supports animal welfare the beef and lamb meat production can bring great values for the environment and community. Within the Scandinavian cross-border cooperation Interreg Öresund-Kattegat-Skagerrak, eight partners have worked together in research and innovation activities during 2016-2019 to meet the challenges in future meat production and consumption. This specific area has a climate suitable for retention. Here we have good water supply and good conditions for grasslands and cattle provides positive added values such as open landscapes, biodiversity, a living countryside, and regional food supply. By finding and visualizing the keys towards a more consumer driven production with improved and consistent beef and lamb meat quality we support the incentives to a production built upon sustainability with a high eating and ethical quality level.

The partners in this project were Aarhus University, Agroväst, RISE, SEGES, Swedish University of Agricultural Sciences (SLU), Svenska Köttföretagen, Svenskt Kött and Økologisk Landsforening. On behalf of all partners, the Lead Partner Agroväst gratefully acknowledge regional funding from the European Union Interreg project Öresund-Kattegat-Skagerrak, Region Midtjylland and Västra Götalandsregionen.

The project´s official final report is published on the project website:

https://agrovast.se/eu-projekt/projekt-x/

August 2020
Ulrika Åkesson, Agroväst
Project manager

Project result in summary

New techniques and methods for improving meat quality

- Based on the research studies done at SLU Götala Beef and Lamb Research, we have found that dairy x beef crossbred steers and bulls had higher carcass weights and carcass conformation scores than pure-bred dairy cattle.
- Based on the studies done at SLU Götala Beef and Lamb Research, an intensive rearing model for ram lambs resulted in higher weight gains and higher carcass conformation scores than extensive rearing, whereas there was no effect on rearing system on technological or sensory meat quality attributes.
- When comparing animal welfare and eating quality attributes on cattle slaughter either at a mobile slaughterhouse or a larger stationary slaughterhouse, no differences were found.
- RISE, in collaboration with Växa Sverige, has evaluated ultrasound scanning as a method for predicting carcass quality traits including marbling in live cattle on Swedish farms. The results indicate that there is potential to use ultrasound to measure the carcass quality traits marbling, subcutaneous fat and muscle depth on Swedish cattle. The ultrasound equipment is robust, portable and non-invasive.

Development of value chain and new business models

- Using transnational research knowledge, Svenska Köttföretagen has made an outline of a new model to be added to the present European standard for classification of carcass quality (EUROP). With this addition it will be possible to change towards a more customer-oriented quality classification of meat based on perceived eating quality.
- Based on interviews and workshops with representatives from the meat value chain in Sweden and Denmark, RISE concluded that a digitisation of the Swedish meat value chain is possible and could generate new opportunities to streamline and optimise production, improve traceability and increase food safety. Furthermore, it could enable a more transparent communication to consumers.
- RISE identified barriers and challenges for a digitisation of the meat value chain in Sweden. One barrier was the need for one influential actor to take lead and the current lack of shared vision and collaboration throughout the value chain. Other challenges were the willingness to invest, how to share data between actors and issues related to ownership of data.
- Transnational studies have been made by RISE and Økologisk Landsforening to visualize the keys in the value chain that can be used to make a change from a push production system to a pull production system. Their work points out that it is of importance how added values are transferred throughout the value chain in examples of long value chains.
- RISE also found that the processing stage and trade are key factors in driving to make a transformation to a more consumer driven meat production.

Efforts towards conscious choices from consumers

- Research studies done at Aarhus University shows that there is some willingness by consumers to pay more for nationally produced meat with higher eating or ethical quality in Norway and Sweden. The willingness by consumers in Denmark is more limited.
- In this project, a new digital education platform has been developed in Sweden by Svenskt Kött: kottskolan.svensktkott.se/kottskolan/

1 Introduction

The objective for this project was to contribute to innovative techniques and methods to support primary producers and process industry to meet demands from different groups of consumers regarding ethical and eating quality of beef and lamb meat in order to strengthen their competitiveness both on national and international markets. The objective was not to stimulate production and consumption of meat in general, but to stimulate towards improved quality and high nature conservation and by this meet the more conscious consumers.

1.1 Activities throughout the value chain

The Scandinavian cross-border cooperation Interreg Öresund-Kattegatt-Skagerrak funded this project by 50% of its total budget, which was MEUR 1.9. Remaining costs was funded by Västra Götalands Regionutvecklingsnämnd and Region Midtjylland. During September 2016 until January 2020, eight partners have collaborated in research and innovation activities to meet the challenges for future meat production and consumption.

Participating partners in this project were Aarhus University, Agroväst, RISE, SEGES, Swedish University of Agriculture Sciences (SLU), Svenska Köttföretagen, Svenskt Kött and Økologisk Landsforening. Cross-border cooperation have been essential in this project. Through active cooperation between countries, representing both research and industry the partners have evolved new knowledge and a network for innovation projects.

In this project, we have had the privilege to work with activities that involve all parties in the value chain, from farmers to consumers. Research has been carried out within primary and secondary production and by involving traders, purchasers and end-consumers. The cross-border partnership of this project with representation from research and industry have strengthened the connections with each other as well as stakeholders in Sweden and Denmark. Distribution of results was also implemented to other Nordic countries.

The partners' work and results from this project have been well covered by external media and partners were active in giving presentations from their specific perspectives at both scientific, agricultural and industry organization meetings.

2 New techniques and methods for improved meat quality

There is a need for new techniques and methods that can support breeders and slaughterhouses to produce and deliver beef- and lamb meat with higher and more diversified eating quality produced in an ethically acceptable way. Partners in this activity have developed, tested and verified different methods and techniques that can support this challenge. Actual and identified needs have been at focus and work have been done in dialogue with the target group and existing technology suppliers to present possible solutions.

2.1 Beef production based on calves from dairy cows by using beef breed sires

It is well known that the use of sex-sorted semen in dairy herds can be a way to increase the value of the carcass by improving both carcass weight and conformation. The effect of using beef breed semen to dairy cows is greatest in intensive rearing systems where the growth potential of the beef breed can best be utilized. We wanted to see if crossing with beef breed could make a difference also in less intensive rearing systems with steers on semi-natural pasture. In this project, therefore, steers of pure dairy breed were compared with crosses between dairy breed and the beef breed Charolais.

2.1.1 Facts about the experiment

In the experiment, pure-bred dairy calves of Swedish Red or Holstein were compared with crossbreds between Charolais and Swedish Red or Holstein. Half of the dairy calves and half of the dairy x beef breed crosses were fed at a higher intensity and the other half at lower intensity. A total of 64 steers were distributed among the four groups.

The high intensity meant spring-born calves that had a long first indoor period on early harvested grass/clover silage supplemented with barley, peas and rapeseed meal, then a grazing period on semi-natural pastures and finally indoor finishing on early harvested silage for slaughter at 21 months of age.

The low intensity meant autumn-born calves that had a shorter first indoor period followed by a grazing period on semi-natural pastures. They had a second indoor period with late harvested silage and a second summer on semi-natural pasture. They were housed for a final indoor finishing on early harvested silage and were slaughtered at 28 months of age.

Animals were followed from weaning to slaughter where for example feed consumption and weight gain was recorded. After slaughter, carcass pH and temperature decline were measured, sections from one hindquarter of each animal was weighed and the strip loin (M. longissimus dorsi) was sampled to assess technological characteristics (tenderness, water holding capacity and color), fatty acid composition and sensory attributes. All meat was aged for seven days then frozen before analysis.

2.1.2 Effect of breed on carcass weight gain

During the rearing, we were surprised that we could not see any difference in weight gain between the dairy x beef crosses and the pure dairy steers, measured as daily weight gain on the living animals. However, after slaughter we could confirm the superiority of the crossbred animals in the form of higher carcass weights.

For steers slaughtered at 21 months of age, the slaughter weight was 32 kg higher for the dairy x beef crosses compared to the pure dairy steers. For steers slaughtered at 28 months of age, the breed difference was 50 kg. So, one should not just look at the liveweight, as it is the composition of the weight gain that matters and effects the carcass weight.

2.1.3 Higher proportion of muscles in crossbreds

There are differences between cattle of dairy breed and beef breed in what proportions they deposit muscles and fat, respectively, which results in a greater proportion of muscles in the beef breeds. The difference in conformation score between the dairy x beef breed crossbreds and the pure dairy breeds was greater for the steers slaughtered at 28 months of age than for those slaughtered at 21 months. Furthermore, the higher conformation score of the crossbreds was reflected in a larger proportion of valuable retail cuts and a smaller proportion of bones. The dairy steers instead deposited more fat, which was reflected in a tendency to a higher degree of visually assessed marbling, intramuscular fat, in the sirloin steak. However, no statistically significant effect of breed could be detected on the fat class or the amount of trim fat.

2.1.4 Impact on fat deposition

The steers slaughtered at 21 months of age had a higher fat class than those slaughtered at 28 months. It is probably because those who were slaughtered at 21 months of age had on average a longer last indoor period before slaughter (163 days) than those slaughtered at 28 months of age (100 days), combined with a higher weight gain during the indoor period than during the grazing periods.

Normally, the fat deposition in cattle grows with increased weight, but in this case, we got fatter carcasses from animals with lower carcass weight, but which had a higher weight gain during the finishing.

2.1.5 Meat quality characteristics

As an indirect measure of tenderness, meat pH is often measured, which should preferably be 5.7 or lower. Although meat from the older steers ended up with a lower pH than meat from the younger ones, both groups had a normal ultimate pH. Despite this, the shear force, the force required to cut through a defined piece of cooked meat, was generally high. It shows that the meat should have been aged longer than the seven days used in this study. As expected, the meat from the older steers was slightly darker than the meat from the younger ones, but otherwise there were no differences in the technological meat quality parameters that were measured. The sensorial evaluation showed that the meat from the dairy x beef crossbreds was coarser, less tender, less juicy and had a sourer taste than meat from the pure dairy steers. Meat from the younger steers had less red colour, was considered to be more tender, and a more intense game flavour. The total proportion of unsaturated fatty acids increased with age, which also was reflected in the proportion of polyunsaturated omega-3 and omega-6 fatty acids. Interestingly, meat from the dairy x beef crossbreds contained a higher proportion of polyunsaturated fatty acids than meat from the pure dairy steers.

2.1.6 Conclusion

It was concluded that using beef breed semen to dairy cows resulted in offspring carcasses with more meat compared with purebred dairy cattle. Variations in a range of characteristics of the meat were found among steers of different breeds having various rearing intensity, but in general the differences of the meat quality were small.

2.1.7 Contact

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2.2 Production models for Swedish lamb meat – effect on eating quality

The objective of this activity was to investigate if the four most common production systems for lambs in Sweden affect eating quality attributes. In 2018, the Swedish sheep and lamb meat production accounted for only 28% of the total Swedish consumption of merely 1.9 kg per capita. Due to an increasing demand among consumers of high-quality lamb meat there is a need to know how lambs should be reared under Swedish conditions, with the goal to obtain a high and consistent eating quality. Consumers define meat quality by its eating properties, where tenderness, juiciness and flavour are the most important factors. The eating quality of Swedish lamb meat varies, which might be due to the many different production systems, including different feeding strategies used. In international studies, it has been shown that diets can affect eating quality of lamb meat. Different feeding strategies, often based on roughage, grazing and grains, can e.g. affect flavour of meat. Hence, the aim of this study was to evaluate the impact of the four most used production systems in Sweden on eating quality attributes of lamb meat.

2.2.1 Experimental set up

In total, 80 crossbred weaned intact ram lambs (Dorset x Fine Wool; 75:25) were assigned to one of four production models for lambs: i) indoor fed with grass and clover silage ad libitum and 0.8 kg concentrate daily per lamb, ii) grazing on cultivated pasture with or iii) without 0.3 kg concentrate supplementation daily per lamb and iv) grazing on semi natural pasture. Treatment groups were balanced for live weight at weening and equal number of twins and triplets. The live weights at start of the experiment were equal between groups (26.6, 27.1, 27.4 and 26.9 for group 1, 2, 3 and 4 respectively). All lambs were weighed each week and the goal was to select lambs to be slaughtered at a fat score of 3 and a live weight of 47-50 kg. At slaughter, carcass weight, dressing percentage, conformation and fatness as well as pH after 24 hours were recorded. Muscle samples were collected from the first eight animals that were sent to slaughter in each of the four groups respectively (a total of 32 lambs). After six days of ageing M. longissimus dorsi were sampled and immediately frozen and stored at -20°C until analyses. Sensory analysis was performed by a trained panel with six assessors. The colour was described according to the CIELAB system in three dimensions representing brightness (L*), redness (a*) and yellowness (b*).

2.2.2 Better conformation with intensive feeding

As expected, the rearing system had a significant effect on live weigh gain (LWG), with indoor lambs having the highest LWG (377 g/day), followed by cultivated pasture + concentrate (287 g/day), cultivated pasture (244 g/day) and semi natural pasture (211 g/day). The days in experiment thereby differed between treatments, from 65, 82, 91 and 109 days for group 1, 2, 3 and 4 respectively. Furthermore, lambs on semi natural pasture had lower conformation score and fat score than the other groups. There were, however, no differences in carcass pH 24 hours after slaughter (ultimate pH). These results show that intact lamb rams can be reared under both intensive and extensive conditions and that would not negatively affect the ultimate pH. However, when it comes to conformation and fatness, a more intensive production, such as group 1, 2 and 3, resulted in carcasses with a significantly higher conformation and fatness score compared to group 4, which could be profitable for the producer when animals are slaughtered. The results suggest that although group 3 were reared at lower intensity than group 1 and 2, this group could finish up for slaughter on only cultivated pasture, as there were no significant differences between group 1, 2 and 3 when comparing conformation and fatness of carcasses.

2.2.3 No major differences in sensory attributes

No meat colour differences between treatments were seen. This indicates that neither LWG nor age at slaughter did effect meat colour, nor did the supplemented concentrate or the different pasture types. The shear force values, a technological difference, did differ between the groups which means that no technological difference in tenderness was found between the different production systems used. Regarding the sensory attribute ‘resistance to cutting’, group 3 (cultivated pasture) was scored lower compared to Groups 2 (cultivated pasture with concentrate) and 4 (semi natural pasture). There was also a strong tendency for Group 4 being scored higher than the other groups for the attribute ‘hay odour’. The more intense odour of meat from lambs grazing semi natural pasture

may be related to the lower growth rate and higher age at slaughter for this group and would be of interest to investigate further. From the results it can be shown that regardless of the differences in diets and resulting growth rate, there were overall very small differences for the sensory attributes. According to these results it could be valid to speculate about individual differences between animals rather than differences due to the different production systems. Normally, growth rate and pH value of the meat are considered as tools to predict sensory attributes, such as tenderness. However, in this study there were no such relationships. This is a very interesting founding since the relationship between pH and eating quality is a measure used internationally to ensure a high-quality meat. Slaughter practices and carcass handling may be different in Sweden compared to big lamb producing countries such as Australia. Therefor it is of further interest to study eating quality of Swedish lambs and how to improve or homogenize the eating quality to ensure a high-quality product to the consumers.

2.2.4 Conclusion

The results from this study indicate that the four different production models, covering the most common Swedish lamb production systems, did not have a significant effect on meat quality parameters such as ultimate pH and colour of lamb carcasses. Sensory meat attributes affected were ‘hay odour’ and ‘resistance to cutting’. With this in mind, it seems that the different production systems tested, besides having an effect on production and carcass characteristics, did not influence eating quality including tenderness and flavour which are the most important traits from a consumer perspective.

2.2.5 Contact

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2.3 Impact of slaughter on meat quality

The objective of this activity was to study animal welfare and meat quality, and their eventual associations, at mobile vs. large scale stationary slaughter. Handling at slaughter exposes the animals to welfare risks and can be very stressful. In addition to reducing animal welfare, stress associated with slaughter may impair meat quality. The effects of mobile slaughter on animal welfare and meat quality have so far not been studied to a large extent.

2.3.1 Facts about the experiment

One small-scale mobile plant, housed in two trucks and parked on farm, and one conventional stationary abattoir, both in Sweden were used in this study. A total of 283 and 281 animals were included at the mobile and the stationery plant, respectively. At the mobile plant, the animals were taken from the stables to an inspection pen, from which the animals were driven along a short driveway to the stunning box. The on-farm observations of the animals included how they were handled as well as the animal's behavior in the driveway to the stun box and in the stun box. Animals slaughtered at the stationary abattoir were transported up to 250 km, and about one third of them were kept in overnight lairage before slaughter. At the stationary plant, the carcasses were electrically stimulated, and Achilles suspended, while at the mobile plant, pelvic suspension was used. At slaughter, blood samples for blood chemistry was taken (cortisol, glucose, lactate), as well as carcass conformation and fat grading, according to the EUROP scale, were registered. After seven days of ageing fat marbling and technological meat quality attributes (pH, thawing and cooking losses, colour, meat tenderness (Warner-Bratzler shear force, compressive load and modulus) were registered.

2.3.2 Results showing no clear differences

There was no clear association between final pH of the meat and the animals' behavioral expression at the start of driving or with the way to drive the animals. However, ultimate meat pH differed between the slaughter plants; carcasses slaughtered at the mobile plant had a higher pH, which could be since electrical stimulation was not used. The percentage of animals with a final pH above 5.8 at cutting was 14.8% at the mobile plant and 7.7% at the stationary one. At both plants, cooking loss decreased with increasing fat class and with increasing marbling.

Shear force and compressive load were higher at the stationary plant, where compressive load was highest in cows and bulls; otherwise the differences between different animal categories were small. At the mobile plant, animals regarded as hesitant prior to being driven had higher, and animals considered as nervous even higher, compressive loads. Both compressive load and shear force were slightly higher in animals staying overnight at the stationary plant.

2.3.3 Conclusion

This project shows the importance of keeping the animals calm when driving to the stun box begins, an appropriate layout of the slaughterhouse premises, driveways and equipment and correct handling of the animals during driving, stunning and bleeding are essential to achieve low stress levels and a high eating quality. There are conditions for good animal welfare and eating quality of meat in both mobile and stationary slaughter of cattle. Based on this project, it cannot be concluded that animal welfare or meat quality is generally better with one or the other way of slaughtering.

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2.4 Innovations to measure meat quality on live cattle

The aim of this activity was to investigate existing techniques to measure meat quality of live cattle and lamb and to evaluate the use of ultrasound to measure meat quality on live cattle in Sweden. Measurements of meat quality in live animals can provide valuable information in the aim to improve meat quality in Swedish beef and lamb. The ability to measure and predict the degree of marbling on live animals could increase interest in eating quality of beef and lamb in Sweden and facilitate production planning, breeding, and slaughter for improved meat quality. Ultrasound is an established method for estimating beef carcass characteristics on live cattle and is used e.g., in the USA and Canada. Meat quality, i.e., sensory quality, includes traits such as tenderness and texture, flavour and juiciness. Tenderness and flavour are the most important meat quality traits and are related to the amount of marbling of the meat, i.e., the amount of intramuscular fat. The marbling of the meat is affected by e.g., sex, age, breed, genetic disposition and feeding regime. Marbling is a moderately heritable in cattle, which means that genetic progress can be achieved by selecting for marbling within a breed.

In Sweden, a standard for beef marbling grading has been developed, which is optional for the slaughterhouses to use. However, few slaughterhouses have implemented the marbling score in their payment model to farmers, which means that there are no obvious financial incentives for meat producers to produce animals of high eating quality.

2.4.1 Techniques to measure meat quality traits on live cattle and lambs

A review of previous literature performed in this project found that techniques that have been tested to measure carcass and meat quality traits is ultrasound, bioelectrical impedance (BIA), computed tomography (CT scan), dual energy X-ray absorptiometry (DXA), 3D-imaging and nuclear magnetic resonance (NMR).

Marbling in cattle can be measured with similar accuracy by ultrasound and BIA and there is potential to develop NMR for use on shallow muscles. However, NMR have so far only been tested in a pilot study on meat samples. Fat and muscles in cattle can be measured with ultrasound, BIA and CT-scan and there is potential to develop 3D-imaging for these traits as well. Fewer studies have focused on eating quality parameters of lambs, and only studies on computed tomography was found. Muscles and fat content in lambs have been successfully measured by ultrasound, BIA, CT-scan and DXA.

In conclusion, ultrasound and 3D-imaging are the techniques considered to have potential to be used for measuring carcass meat quality traits on live animals in Sweden.

2.4.2 The use of ultrasound to predict carcass meat quality traits in Swedish cattle

The study was performed on 95 heifers and cows of various breeds. The animals were scanned both at the 12/13th rib, which is the most common site in in the literature, and at the 10/11th rib, where Swedish carcasses are parted in quarters. The ultrasound measurement included marbling score, backfat thickness and muscle depth. The correlation between ultrasound marbling score and carcass marbling score was r=0.46 for measurements between 12/13th rib and r=0.35 for 10/11th rib (p<0-001). The correlation between ultrasound backfat thickness and carcass backfat thickness was r=0-64 (p<0-001) for both the 12/13th rib and the 10/11th rib. The deviation between ultrasound and carcass backfat thickness increased with animal fatness. The correlation between ultrasound muscle depth and carcass muscle depth was r=0.51 at 12/13th rib and r=0.43 at 10/11th rib (p<0-05).

Most of the carcasses were graded as marbling score 1 or 2 (table 1), which means that the distribution of data was limited, and that correlation may not be the best analysis method. Therefore, the marbling score was also analyzed as a categorical variable with Fisher's exact test, which showed a significant relation between ultrasound marbling score and carcass marbling score (p<0-001). The ultrasound measurement classified the carcass marbling score correctly in 48% of the cases for the 12/13th rib and in 52 % of the cases for the 10/11th rib. In general, the marbling score seemed to be underestimated, which indicates that a better result might be achieved by recalibration of the software that evaluates the ultrasound images.

Fatter animals are known to be more difficult to measure with ultrasound, which corresponds to our results. The animals in this study were also generally fatter compared to the animals included in other studies. A relatively high number of ultrasound images was removed during image analysis due to low quality. Previous studies have shown that the experience of the ultrasound technician and the image interpreter may have impact

on the results. These factors could most likely explain why the correspondence between ultrasound and carcass measurements was lower compared to previous studies.

2.4.3 Conclusion

There is potential to use ultrasound to measure marbling and meat quality traits on Swedish cattle. However, an increased data material with better distribution including more high marbling scores is necessary to get more reliable results. Furthermore, greater knowledge and experience related to the ultrasound technique is expected to improve the results.

Table 1. Ultrasound estimation of marbling score at two different positions, between 12/13th rib and 10/11th rib, in relation to carcass marbling score. Number of animals graded within each marbling score and percentage of animals within ultrasound marbling score and corresponding carcass marbling scores after slaughter

		Carcass marbling score					
Ultrasound marbling score	**Position**	**1**	**2**	**3**	**4**	**5**	**Total sum**
1							**38**
	12/13	23 (61%)	11 (29%)	3 (8%)	1 (3%)	0 (0%)	**(100%)**
	10/11	23 (64%)	10 (28%)	2 (6 %)	1 (3 %)	0 (0%)	**36 (100%)**
2							**52**
	12/13	13 (25%)	21 (40%)	17 (33%)	1 (2%)	0 (0%)	**(100%)**
	10/11	12 (23%)	22 (42%)	15 (29%)	2 (4%)	1 (2%)	**52 (100%)**
3	12/13	0 (0%)	0 (0%)	1 (33%)	1 (33%)	1 (33%)	**3 (100%)**
	10/11	0 (0%)	0 (0%)	3 (100%)	0 (0%)	0 (0%)	**3 (100%)**
4	12/13	0 (0%)	0 (0%)	0 (0%)	0 (0%)	0 (0%)	**0 (0%)**
	10/11	1 (100 %)	0 (0%)	0 (0%)	0 (0%)	0 (0%)	**1 (100%)**
Total sum	**12/13**	**36**	**32**	**20**	**3**	**1**	**92**
	10/11	**36**	**32**	**21**	**3**	**1**	**93**

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2.4.5 Read more

In Swedish

Gustafsson, L. & Lindahl, C. 2019. Tekniker för att mäta köttkvalitet och slaktkroppsegenskaper på nötkreatur och lamm före slakt. RISE rapport 2019:76. Jordbruk och livsmedel, RISE Research Institutes of Sweden, Uppsala/Skara.

Gustafsson, L. & Lindahl, C. 2019. Ultraljud – mätning av köttkvalitet på levande nötkreatur. RISE rapport 2019:78. Jordbruk och livsmedel, RISE Research Institutes of Sweden, Uppsala/Skara.

3 New techniques and methods for improved meat quality

Consumers are willing to pay for high ethical and sensory quality of meat. There is a need for incentives in the value chain to give feedback in a pulling production system to ensure that breeders and slaughterhouses see the benefits in meeting demands from different consumer groups. By doing this we can strengthen the competitiveness and profitability in regional meat production. A frequent dialogue with the target group have been necessary to catch actual needs and to contribute to efficient exchange of knowledge.

3.1 New price model strategy for slaughtering

By adjusting or adding pricing parameters to the EUROP-standard we can improve conditions and competitiveness for lamb and beef producers. It is common that premium quality beef and lamb meat are imported from Australia, Brasil and United States. Improved eating quality of Swedish lamb and beef meat add values to the already important ethnical values as for example animal welfare, low use of antibiotics. In this activity literature studies have been made together with an active dialogue with industry representatives to find ways for a change adapted to Swedish production conditions.

3.1.1 Facts about the study

Research expertise from partners of this project have been contributing with their knowledge of how technological meat quality attributes could be used as parameters in a price setting model focusing on eating quality.

A review was conducted of various measurement techniques for assessing meat quality in lamb and beef after slaughter. The review was mainly based upon searches in databases of scientific literature, but also on discussions with industry people and colleagues.

The review, made by RISE, shows that several attempts have been made to find objective measurement methods for assessing and potentially classifying meat quality. Many promising results have been reported in the literature.

Yet it is difficult to make any recommendations on one single salvaging technique based upon these results. Possibly, the technology that is currently attracting the most attention and hopes is hyperspectral image analysis, especially if the intention is to find a technology, suitable for forming the basis for a classification system. In such a context,

hyperspectral imaging is a technology that meets many positive criteria: it is contact-free, it has spatial resolution, it combines advantages of both vision and NIR. There are also several studies that show promising results, and there is still good hope that the technology will develop further in near time (both in terms of price and performance), hand in hand with the trend in society towards increased digitisation (i.e. development of artificial intelligence, better and cheaper sensors, increased access to computational power, connected devices, etc.)

A literature review conducted by Aarhus University forms the basis of the model. The literature review shows, among other things, that beef is perceived as especially tasty when we experience clear salt, sweetness and umami flavours. The study also showed we better accept and appreciate the taste of grass and game more in Europe than in the US. The parameter that seems to be the most significant for the taste of beef is the intramuscular fat.

The outline of new model for predicting meat quality is inspired by the Australian model Meat Standard Australia. The model includes several quality parameters, each describing different quality characteristics of the beef. The various parameters are:

- pH
- Marbling
- Fat
- Category of
- Weight
- Fattening
- Age
- Number of days for tenderisation
- Type of tenderization

3.1.2 Conclusion

Based on scientific literature within the framework of this project, an outline for a new model for predicting meat quality for Swedish and Danish conditions has been developed within this project. Svenska Köttföretagen has made this outline of a new model to be added to the present European standard for classification of carcass quality (EUROP). With this addition it will be possible to change towards a more customer-oriented quality classification of meat based on perceived eating quality.

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3.1.4 Read more

In Swedish

Isaksson, I., Wahlund, L., Lindahl, C. 2019. Tekniker för att mäta kvalitet på nöt- och lammkött efter slakt [Techniques and methods to measure beef and lamb meat quality – a review]. RISE-rapport 2019:52. Jordbruk och livsmedel, RISE Research Institutes of Sweden, Göteborg/Uppsala.

Link read more: http://urn.kb.se/resolve?urn=urn:nbn:se:ri:diva-38808

3.2 Digitalisation and techniques for traceability

Sweden ranks highly in terms of digital development. The ongoing industrial digitisation encompasses all sectors and represents a dramatic change with entirely new conditions and opportunities as a result. Agriculture is also facing extensive digitisation development, but the progress is in its beginning and has not yet reached its full potential.

Automation of work tasks has become commonplace for many primary producers with livestock, e.g. the use of milking robots and selection gates as well as automated feeding, weighing of animals and manure and litter handling. Advances in automation and digitisation may be crucial for a sustainable increase in agricultural productivity and the future competitiveness of agricultural businesses. So far, the technical development has mainly been within crop management and milk production, while meat production still has a limited technical development. In fact, the entire meat supply chain is characterized by a low degree of digitisation and automation. A digitisation of the meat chain requires electronic identification of animals (e.g. RFID tags) to enable automated data management, advanced data analysis and decision support systems. The technology and systems need to be adapted to industry-wide scale to increase the innovation power and utilize the full potential a digitalisation could provide in terms of e.g. more secure traceability, increased food security and increased meat and meat product diversification. The latter is not least important: quality sorting of animals and meat provides opportunities to increase profitability, create a more demand driven production and develop new business models and products. By digital solutions, cutting details can be more securely traced through the value chain from farm to consumer and more detailed information of the production can be communicated to the consumer.

This means that consumers are enabled to make more decision driven choices based on their specific preferences. This increases transparency and consumer trust and can be an aid to convey added values of products and increase consumer understanding related to the effects of their choices.

The aim of this project activity was to investigate how a digitalisation of the meat chain could be designed and practically be implemented in Sweden. Furthermore, the aim was to identify the drivers and barriers for increased digitisation and automation of the meat supply chain as well as relevant actors' needs and demands for information flow and data sharing. Finally, we aimed to show what added values a digitalisation of the meat supply chain could provide in terms of increased efficiency and productivity, more secure traceability, and a more transparent production all the way to the consumers.

3.2.1 Facts about the study

The first part of the study aimed to investigate how other countries have implemented and developed a digital meat supply chain. As Denmark has implemented electronic ear tagging as a legal requirement for production animals, the experience and knowledge of this process in Denmark was considered a valuable information source. Therefore, study visits and interviews with Danish farmers, advisors, veterinarians and slaughterhouses were conducted. Similar study visits and interviews were also conducted in Sweden to identify different perspectives of the drivers and barriers for increased digitisation and automation of the Swedish meat supply chain. In addition, an interview study was conducted with Swedish farmers, who use electronic ear tags today, to elucidate the areas of application, perceived added values and future needs. Finally, a workshop was

arranged with representatives from various actors in the meat supply chain as well as relevant technology businesses to discuss drivers and barriers and the potential of a digital meat supply chain in Sweden.

Many countries have already implemented digitisation in meat production several years ago, for example Denmark, Estonia, Canada, Australia and New Zealand. In Denmark, electronic ear tagging of production animals became a legal requirement in 2010. It was the industry itself that initiated the process of implementing electronic ear tags as they were in agreement of the benefits it provided. The industry has been positive to the implementation and there has been a good dialogue between all actors concerned in the meat supply chain during the implementation process. Experiences from Denmark is that the implementation process takes time, despite enforcement by legal requirements of electronic ear tagging. An estimation was that the full potential of the electronic ear tags and digitisation process will be reached in another 10 years at least.

3.2.2 Conclusion

The results of this study showed that the Swedish meat industry generally is positive to an implementation of a digital meat supply chain. The advantages identified were that the digitsaton can be used to optimise production processes, increase food safety, increase data security and increase advisory and veterinary services. However, the industry is also aware of the initial cost a digitalisation will require due to investments in digital systems and various technical solutions, and this was considered a major barrier. The Swedish government has given the authorities an assignment to work for increased digitalisation within the food supply chain, but a decision to enforce transformation e.g. through legislation is not of current interest and no actor is actively pursuing the issue.

The representatives of actors from the meat supply chain involved in this study, i.e. authorities, farmers organisations, slaughterhouses, advisory companies and veterinarians, all agreed that a digitalisation of the meat supply chain can contribute to increased efficiency and has a number of potential benefits. Furthermore, all representatives could identify benefits in their own operations, however no specific player was identified to be responsible to initiate and drive the development. In the interviews with the Swedish actors, it appears that there are those who advocate that electronic ear tagging should be introduced as a legal requirement and that it is a prerequisite for the implementation to be successful, while others believe that the process should be voluntary. Some of the arguments that emerged were that the digitisation should be voluntary in order not to burden farmers with extra costs and that there is a risk that farmers will feel controlled and that they lose power of their own herd data. On the other

hand, it was argued that there must be a legal requirement to be able to unite the industry, get everyone working towards a common goal and to get a quick implementation process. Authorities and industry organizations need to take the initiative to demonstrate the need for a digitized meat supply chain and clearly take a position on the issue. The challenge is that there is no obvious player who should drive the issue, and a decision is needed right up to the government level for the Board of Agriculture to be able to act for a digitisation. For example, subsidizing the transition to digital technology could be a driving factor. Cross-border collaboration between the actors across the entire value chain and a concrete dialogue is needed to agree on an approach that everyone can support.

Unity in the industry has been an important factor in the success Denmark has had with the introduction of electronic ear tags. Another important issue that needs to be clarified is who owns the data that can be recorded and logged due to the digitisation. In order to take advantage of the opportunities that are created by the transformation, actors need to be willing to share data with each other and agree on what data to share.

The systems need to be secure, for all players to feel confident in sharing data and increasing transparency. Several technical issues need to be addressed as various existing systems in the chain need to be linked together, so that data can safely flow between them. Software programs need to be developed so that the data collected can be used effectively to improve and optimise processes and flows as well as monitor and evaluate production.

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3.2.4 Read more

In Swedish

Lind, A. & Lindahl, C. 2020. Möjligheter och utmaningar med en digitalisering av köttkedjan. RISE rapport 2020:14, Jordbruk och livsmedel, RISE Research Institutes of Sweden, Uppsala.

3.3 Description of value chain and value flow analysis

The meat production of today is a pushing system with relatively vague connection to actual customer demand. In this activity the objective has been to describe the value chain and make value flow analysis showing how to strengthen options which supports efficient and consumer driven cooperation throughout the value chain. It has also been a platform for developing, testing and implementing best practices between our countries. Økologisk Landsforening has presented four different cases in Denmark focusing on ethical values: 1) meat production from Jersey cows, 2) meat from grass-fed cattle "Naturkød", meat from grass-fed lamb and 4) economic value chain from a farm shop. The common feature of the four value chains was that the products are branded and produced with ethical values as animal welfare, biodiversity and climate as part of the product concept.

Value chains built on ethical values need to include high eating quality. To be successful in shorter value chains, producers need to put effort in product marketing focusing on the added values. Further, it is necessary for the business to establish clear and long-term contracts from the start between all partners involved in the value chain. To succeed with clear contracts between partners, the communication between all parties needs to be clear to be able to define the common concept and ethical values of the product chain.

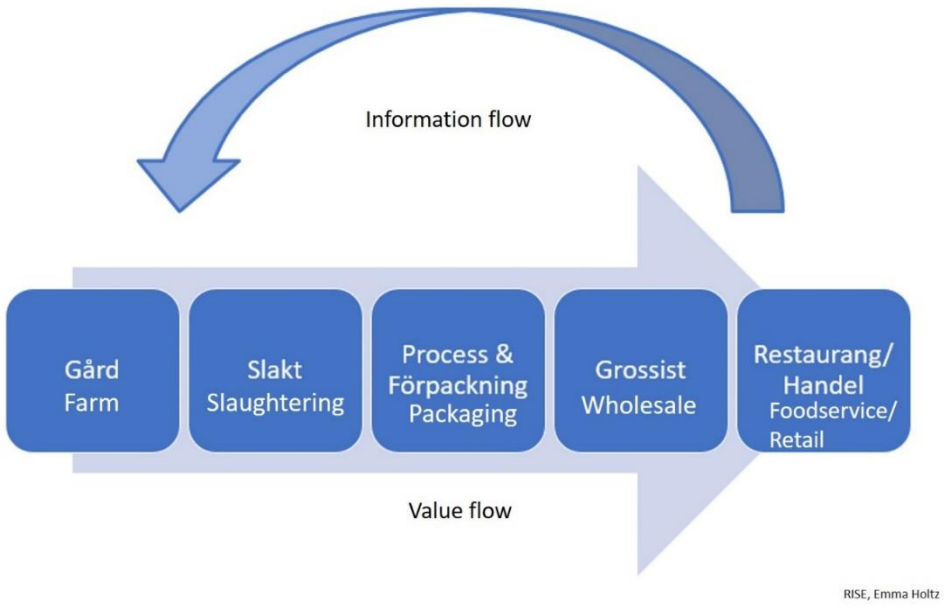
Additionally, the consumers will require a higher understanding concerning the ethical values of the products to increase the sales of beef and lamb meat. Studies done by Økologisk Landsforening within in this project showed that consumers have expectations that nationally produced meat is of higher quality than imported meat.

In an economic perspective looking at the farm shop concept, we saw the need of understanding the carcass calculation, both when it comes to demand and time-investment. By analyzing a traditional value chain in Sweden and a short value chain in Denmark RISE has studied the information flow between the partners in the value chain to better understand influencing factors on production control.

From these studies, based on specific cases and interviews the main obstacles for a more consumption driven value chain of high-quality meats were pointed out. Addressing the identified obstacles with suggested improvements are a step toward a more pulling, consumer-driven, production system. In general, an increased cooperation regarding

planning, sharing of information and agreement on quality focus is necessary to improve the value chain for high quality meats.

Fig. Beskrivning av informationskedjan



RISE, Emma Holtz

3.3.1 Conclusion

In this project, different communication tools have been developed to strengthen the communication between partners in the meat value chain to support a more successful development of the meat value chains in the future with focus on high quality meat. During the project period, there has been ongoing activities supporting matchmaking and networking between producers and consumers resulting in new collaborations and products. The interviews of the different parties of the value chain showed that one of the key factors to be successful in promoting added value products from beef and lamb meat is to agree upon how the concept is defined according to the added values and how to communicate them throughout the value chain, all the way from producer, slaughterhouse, packaging and trade. In this study we show that slaughterhouses, wholesalers and retail hold the key to enabling a more consumer driven production system for high quality meat; this, through an increased quality focus as well as collaboration and agreements in the value chain.

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4 Efforts towards conscious choices by consumers

In general, Danish and Swedish consumers have limited knowledge when it comes to ethical aspects of meat production and eating quality. However, due to the home-cooking trend, interest in meat quality and how it is produced is growing. Some consumers choose to reduce their meat consumption for health- and/or environmental reasons, but when they eat meat, many of these consumers are believed to look for high quality meat products. In future, labelling products with added values connected to animal welfare and eating quality is expected to become more important throughout the value chain.

4.1 The link between animal welfare and quality

Animal welfare is an issue that is seen as important by an increasing number of consumers and actors in the value chain from farm to fork. However, this awareness is not necessarily reflected in the production and consumption of beef and lamb as there are different understandings of what constitutes good animal welfare and how this can be promoted.

To get a better understanding of how consumers and value chain actors perceive animal welfare and the link to quality, we have conducted both qualitative and quantitative consumer studies and interviewed various actors in the value chains for beef and lamb.

4.1.1 Facts about the focus group study

In order to develop a better understanding of how Scandinavian consumers view beef and lamb and the link they see between animal welfare and quality, focus groups with consumers were conducted in Denmark, Norway and Sweden in late 2017 and early 2018. In each country two focus group interviews were conducted. The number of participants was between 7 and 11 respondents. In total 55 consumers participated in the focus groups.

4.1.2 Results of the focus group study

Results showed that national origin of beef and lamb is associated with high quality, animal welfare, trustworthy producers, and food safety by Scandinavian consumers, with Swedish consumers having least trust in imported meat. Focus group discussions reflected geographical differences between countries. In Norway and Sweden, participants were thus conscious of large distances and had preferences for local production. Focus group participants in Norway and Sweden expressed a willingness to pay for higher animal welfare and acknowledged that they had a responsibility for the conditions that animals were subjected to. In contrast, Danish consumers expressed higher price consciousness and that the distance between farm to fork was more a mental than geographic distance. Danish consumers thus felt distanced from food production. They acknowledge that consumers *should* be responsible, but there was less indication that they were taking responsibility to the same degree as Norwegian and Swedish consumers. Danish consumers were also less concerned about imported meat. To some extent at least, this reflected strong confidence in how Danish authorities monitor both domestic production and imports of foods.

Regarding the link between animal welfare and quality, the focus groups suggested that there are differences in perceptions between countries. The focus groups indicated that lamb and sheep meat is most popular with Norwegian consumers, while lamb meat consumption is very seasonal in Denmark and Sweden.

Norwegian consumers regarded lamb meat as high quality. Local/nationally produced beef and lamb meat were also associated with high levels of animal welfare. Buying meat of local/Norwegian origin production also supports small Norwegian producers. Focus group participants were not aware of any animal welfare labels, but anyway thought that these would just be adding costs without improving animal welfare over conventional Norwegian production.

The Swedish focus groups indicated that national origin is even more important to Swedish consumers, who associate imported meat with lower quality and poorer animal welfare. It was recognised that how meat is processed after slaughtering can be important for eating quality. Swedish consumers were willing to pay more for locally produced beef.

Finally, the Danish focus groups indicated that Danish consumers are very price focused. However, this is not necessarily understood as being detrimental to animal welfare. Danish consumers were very interested in value for money, with some consumers being concerned about animal welfare labels leading to higher prices. Labels were seen as more about branding and storytelling than about the conditions of the animals.

4.1.3 Facts about the quantitative consumer study

Based on the results of the focus group interviews, we designed a survey to obtain further insight into how Scandinavian consumers perceive the impact of animal welfare on eating quality and their willingness to pay for beef and lamb. The quantitative study was conducted during the winter of 2019 and included 511 and 569 respondents in Denmark and Sweden respectively. Approximately 50 percent of the respondents were male (56.1 percent in Denmark, 50.3 percent in Sweden), and there was a good spread across various socio-demographic variables such as age, education and geography. The questionnaire covered a variety of topics, including items from the *Modular Food Related Lifestyle* instrument.

4.1.4 Questionnaire results

The results of the quantitative study show that both Danish and Swedish consumers believe that good animal welfare leads to better eating quality. This belief was slightly stronger among Swedish than Danish consumers.

Furthermore, our analysis shows that this perception was more prominent among consumers from rural areas compared to consumers from bigger cities in Denmark, and consumers from smaller cities and rural areas in Sweden were more convinced compared to urban areas.

Overall, consumers from both Denmark and Sweden feel a moderate sense of responsibility for the production conditions, sustainability, and environmental impact of the food they consume. However, when looking at the individual items it becomes clear that the Danish consumers are more *concerned* about the conditions under which their food is being produced. Taking the results from the preceding focus group interviews into account, this difference could be due to a higher level of *trust* of Swedish consumers in Swedish production regarding animal welfare. On the other hand, Swedish consumers to a higher degree try to buy sustainably produced food, which might indicate a higher sense of responsibility in Swedish consumers.

The results indicate that animal welfare and organic labels affect the consumers' choice of meat in both Denmark and Sweden. A relatively high percentage of both Danish and Swedish consumers indicated that animal welfare or organic labels always or sometimes influence their choice of meat, and consumers from both countries look for labels when they do groceries. However, the results indicated that there was a higher level of uncertainty among the Danish consumers as to which labels, they should look for. Furthermore, while especially the Danish consumers associate animal welfare labels with good animal welfare, they also associate the labels with attempts to create additional sales (upselling) and branding strategies. In contrast, Swedish consumers associate

labels with higher product quality. This is reflected in a higher degree of willingness-to-pay for labels in Sweden, but both countries agree that they would buy more animal welfare/organic labelled products if they were cheaper.

Although there generally seems to be a low level of willingness-to-pay for lamb and beef, the results of the present study reveal other ways Danish and Swedish consumers differ. The results thus indicate that Danish consumers are more price-conscious than Swedish consumers. However, this does not necessarily mean that everything has to be cheap, but that price is an important factor when Danish consumers make their choice in the shop. Furthermore, Danish consumers' willingness to pay increases when they are shopping for special occasions, while country of origin is especially important for Swedish consumers, who prefer national or locally produced meat.

4.1.5 Conclusions of consumer studies

Overall, the results of the consumer studies indicate that there is a potential for selling more meat produced with a high animal welfare standard. However, this is dependent on consumers having trust in the animal welfare claims made. It is also important that the eating quality is high, as otherwise willingness-to-pay will be compromised.

4.1.6 Selling welfare beef and lamb to consumers

In addition to the qualitative and quantitative consumer studies, we have interviewed actors along the value chain from farm to retail store in order to gain a deeper understanding of the role animal welfare plays for their perception of the quality of beef and lamb. We understand a value chain to be an expression of the links that exist between primary producers, slaughterhouses, processors, distributors and consumers around the production, processing, marketing and consumption of particular beef and lamb products.

4.1.7 Facts about the value chain study

In Denmark and Sweden, we interviewed producers, manufactures and distributors. In selecting the informants, we aimed to cover the entire value chain and both large and small actors. Despite numerous attempts to get in contact with representatives from the retail sector, we unfortunately did not succeed in neither Denmark nor Sweden. This is a limitation of the study.

We conducted a total of 14 interviews, seven in each country. All interviews were recorded and transcribed verbatim. The interviews were semi-structured qualitative interviews. The interview guide was based on 'market-practice theory' and supplemented with questions about the value of animal welfare. We asked informants about (1) their perception of the market, who they see as the central actors, and any likely changes in the market; (2) how they perceived animal welfare and the perception of standards for these kinds of products; (3) how the collaboration in the value-chain worked and what kind of promoting activities were undertaken; and (4) if they wished to make any additional statements.

4.1.8 Results of the value chain study

Our analysis of the interviews showed that it is important to keep in mind that 'value' has a double meaning. Value has both an economic dimension and a normative/ethical

dimension. If animal welfare has no economic value, it is impossible to have good animal welfare in the long run as it is associated with extra costs. Without normative/ethical value, animal welfare is reduced to minimum standards, which are unsatisfactory for many of the actors we interviewed. They want to go beyond the legal minimum requirements. In the analysis, we have tried to capture what is necessary to take both meanings of value into account across the value chain from primary producer to the end consumer.

In both Denmark and Sweden, our study shows that beef and lamb with good animal welfare are sold through two types of value chains that handle the challenge of profitably maintaining the normative value of animal welfare quite differently. First, there are long value chains, where meat labelled as produced with high animal welfare standards is sold through traditional retail stores. These value chains are characterised by a low degree of personal interaction, a demand for large quantities of meat and reliable supplies (from the retailers) and quite stable expectations towards what constitutes animal welfare. Because of the low degree of personal interaction, long supply chains face a challenge regarding communication. This challenge is typically using animal welfare labels and third-party certification of the animal welfare requirements met.

The standardisation of animal welfare means that it is often difficult for producers to cover their costs if they go beyond the requirements of the standard but means that the customer knows exactly what they are paying for.

In contrast, short supply chains, as we have chosen to call them, are characterised by few intermediaries in the value chain between primary producer and end consumer, small volumes, and dynamic expectations. That there are few or no intermediaries between them makes a high degree of personal interaction between producer and customer possible, which facilitates communication of the specific animal welfare aspects and other qualities that characterise the meat that is produced and sold. The downside of this is that it is difficult to increase the scale of production. Each primary producer has a limited stock of animals and buyers often do not know when and how much meat they are able to buy from the supplier.

This makes these producers less attractive for large buyers, who require reliable supplies. Hence small-scale producers are often not certain that they will be able to sell all the meat from the animals they produce.

Animal welfare is an issue that is considered important to actors along the entire value chain. However, our study shows that different actors have different and to some extent opposite expectations regarding animal welfare, which makes doing business together difficult. At the same time, our study underlines the importance of seeing animal welfare in relation to other issues that are regarded as important by society, not least sustainability, CO_2 emissions and the environmental impact of animal production more generally.

4.1.9 Conclusions

There is no market for animal welfare out there that just waits to be served. The market for beef and lamb produced with a high level of animal welfare is constructed through a myriad of interactions between primary producers, processors, wholesalers, retailers, restaurants, and consumers. These actors often have different understandings of what constitutes good animal welfare. It is therefore important to have high levels of trust in primary producers actually living up to their promise with regard to animal welfare.

In short value chains trust can be built through personal interactions, while in long supply chains it is important to develop credible animal welfare labelling schemes.

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4.2 Efforts towards more conscious consumer choices

To meet the need to increase the consumers knowledge of animal welfare and meat quality Svenskt Kött has developed Köttskolan.se an e-learning for staff in the FMCG companies and for consumers. Köttskolan.se is free of charge and open for everyone.

4.2.1 Facts about the educational web platform

The purpose is to collect and illustrate facts about meat, meat quality and Swedish added value in an educational and appetizing way. The target group should be able to follow a training plan and acquire knowledge at their own pace and according to their own interests.

We want to meet the retail store employee and the consumer and help them gain more knowledge.
Köttskolan.se contains 62 lessons divided into 8 courses:

- Seasons and meals
- Handling of meat
- Cook meat
- Temperatures
- In the grocery store
- Meat and health
- Why Swedish meat?

4.2.2 Short term result

The goal of the project was for 500 people to have registered at Köttskolan.se within one year from launch, which was on September 20, 2017. On September 20, 2019, the number of registered users was 872.

- 872 registered users on Köttskolan.se
- Almost 600.500 side views on Köttskolan.se
- Over152.000 unique visitors
- Almost 90.000 views of the films on YouTube
- Most popular lessons: Meat for cooking sous-vide, How to fry meat in the pan, To freeze and thaw meat, Characteristics of different packages.

4.2.3 Long term result

Köttskolan.se is now part of the ongoing operations at Svenskt Kött and is included in the planning for the future. As it is completely digital and searchable on the internet, it is being spread all the time if it is relevant to the target audience. Therefore, it is important to constantly analyze statistics and develop Köttskolan.se according to consumers' interest in learning about meat quality and animal welfare, which is also done. Denmark has, during the project, been following the work done in Sweden. Økologisk Landsforening will post project investigate the possibilities to create something similar in Denmark. Within the project Økologisk Landsforening has created marketing material build on the described value chains and according to the result from Aarhus University and RISE.

4.2.4 Contact

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4.2.5 Read more

Educational web platform: www.kottskolan.se

Through our international collaboration programmes with academia, industry, and the public sector, we ensure the competitiveness of the Swedish business community on an international level and contribute to a sustainable society. Our 2,800 employees support and promote all manner of innovative processes, and our roughly 100 testbeds and demonstration facilities are instrumental in developing the futureproofing of products, technologies, and services. RISE Research Institutes of Sweden is fully owned by the Swedish state.

I internationell samverkan med akademi, näringsliv och offentlig sektor bidrar vi till ett konkurrenskraftigt näringsliv och ett hållbart samhälle. RISE 2 800 medarbetare driver och stöder alla typer av innovationsprocesser. Vi erbjuder ett 100-tal test- och demonstrationsmiljöer för framtidssäkra produkter, tekniker och tjänster. RISE Research Institutes of Sweden ägs av svenska staten.

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