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Department of Molecular Sciences

What does beef taste like? – A sensory study for development of beef terminology

Vad smakar nötkött? – En sensorisk studie för utvecklandet av en nötköttsterminologi

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Abstract

Today, there is no general terminology to describe the sensory properties of beef. Hence, the aim of this study was to develop a terminology to describe the sensory texture, flavour and appearance properties of beef. Attributes describing beef were chosen from earlier studies and a qualitative open discussion. The sensory quantitative method that were used to validate the words chosen from the open discussion were CATA, “Catch-all-that-apply” with 30 respondents. Colour- and pH measurements were also performed to see if there were any significant differences between the meat samples and if there were any correlations between pH and colour values and the generated terminology. The muscle that was analyzed were Strip Loin *(M. longissimus dorsi)* from four cattle.

The terminology established by the 30 respondents generated 7 texture-, 7 flavour- and 9 appearance attributes. The most common flavour attributes, that over 50 percent of the panelists seemed to perceive in at least one of the four meat samples during the sensory method CATA, were umami, mineral, moderate meaty, nutty, buttery, mellow and mature. The texture and appearance attributes generated in the same way was juicy, tough, tender, firm, soft, dense- and porous fiber structure, clear and dark red, homogeneous colour, poorly-, moderate- and richly marbled, fibery, moist and smooth. The pH analysis showed no statistical difference between the samples. The colour analysis on the other hand did show a statistical difference. Any correlation between the terminology and the obtained values from pH and colour measurements could not be found.

Keywords: Sensory, sensory marketing, beef, Strip Loin, cattle, meat, CATA.

Sammanfattning

Idag finns det ingen generell terminologi för att beskriva de sensoriska egenskaperna för nötkött. Målet med denna studie var att utveckla en terminologi för att beskriva den sensoriska texturen, smaken och utseendet av nötkött. Attributen som valdes för att beskriva köttet hade sitt ursprung från tidigare studier och en kvalitativ öppen diskussion. Den sensoriska kvantitativa metoden som användes för att validera orden valda från den öppna diskussionen var CATA, ”Catch-all-that-apply” med 30 respondenter. pH- och färgmätningar utfördes även för att se om det var några signifikanta skillnader mellan proven och om det fanns några korrelationer mellan pH- och färgresultat samt den genererade terminologin. Muskeln som analyserades var ryggbiff *(M. longissimus dorsi)* från fyra nötkreaturdjur.

Terminologin som fastställdes av de 30 respondenterna genererade 7 textur-, 7 smak- och 9 utseendeattribut. De vanligaste smakattributen som över 50 procent av panellisterna tyckte sig känna i minst ett av de fyra köttproven under den sensoriska CATA-metoden var umami, mineral, måttlig köttsmak, nötig, smörig, mogen och mustig. De texturattribut som genererades på samma sätt var saftig, seg, mör, fast, mjuk, tät- och gles/porös fiberstruktur. Utseendeattributen som genererades var klarröd, mörkröd, homogen färg, svagt-, måttligt-, och rikligt marmorerad, fuktig, fibrig och slät. pH analysen visade inte på någon statistiskt signifikant skillnad mellan köttet från de olika proverna, medan färganalysen gjorde det. Någon korrelation mellan terminologin och de erhållna pH- och färgvärdena kunde inte hittas.

Nyckelord: Sensorik, sensorisk marknadsföring, nötkött, ryggbiff, nötkreatur, kött, CATA.

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1 Introduction

1.1 Problem description

Basically, the eating quality of meat can be described as good, very good or bad. The average consumer is talking about meat in terms of “tough”, “tender”, “juicy” and “dry”, but is that it? How would it be if a piece of meat was described in the same way as we describe wine? A Rib Eye steak with intense meaty flavour and notes of grass and caramelized butter sounds more interesting than just a Rib Eye steak. To reflect upon the aromas from what you have on the plate can both give you a greater eating experience and make you consider what type of meat that you are buying. In today’s society, we might probably need to reflect over our meat consuming habits. To just buy meat because it is convenient to prepare, is probably not good for neither the climate nor for our health. In statistics from the Swedish Board of Agriculture (Jordbruksverket) it has been shown that the overall consumption of beef in Sweden, measured as carcass weight usage, has decreased since 2014 while the consumption of Swedish beef, in the same period has increased (Jordbruksverket, 2019a). Therefore, it can be concluded that Swedish consumers buy and eat less meat but the meat they are consuming has its origin from Sweden in a greater extent today than before. To maintain this trend, it is important for the meat companies to highlight the advantages with meat produced in Sweden. It is also important to make meat something valuable, almost luxurious, that the consumers are willing to pay extra for. To look into and be inspired by the wine industry that nowadays are selling a drinking experience rather than just something to drink could be one possibility. In the year of 1957 Systembolaget (the state-owned chain of liquor stores in Sweden) had a marketing plan called “Operation wine” to change the Swedes thought about their drinking habits (Systembolaget, n.d.). To change the drinking tradition from spirits to an alternative with lower percent alcohol, such as in this case wine, was not an easy task for the state-owned company.

It was not until nine years later, 1966, wine reached a higher sale than spirits and this with a market plan that pointed out the benefits with the aromatic wine that suited perfect with delicious foods. Unfortunately, wine and meat are not sold under the same conditions and to change people's mind about meat and make it more valuable is not something that will happen over a night. To learn from the wine industry and draw attention to the eating experience and how to describe the products could be one alternative for meat to reach a higher status. To point out the benefits with Swedish meat due to high standards regarding among others animal welfare, antibiotic use and climate impact could be another alternative. Meat from production systems including added values such as these, have a higher value for the consumers and can thereby have a higher price tag. A decreasing meat consumption would therefore not be the end for the meat industry, it would rather be the beginning.

1.2 Purpose

The aim of this study is to investigate:

- If it is possible to generate a terminology to describe the taste, texture and appearance of beef, using two sensory methods. One qualitative method, an open discussion with a panel and one quantitative method, CATA (Check-all-that-apply) with untrained respondents.
- If there are any correlation between colour and pH of the beef and the generated terminology.

The purpose of the present thesis was also an attempt to provide insight and knowledge on how to market beef in a more describing and attractive way.

2 Literature background

2.1 Do we need meat?

Meat and especially red meat have been a part of the human species diet for at least 2,6 million years (Wyness, 2016). Researchers have suggested that a diet without meat in the early history of the human would probably have resulted in a less evolved brain. This protein rich food could therefore have had a greater significance than we ever could imagine. As the agricultural methods evolved, including domestication and genetic selection of wild life, we no longer were dependent on hunting to survive. These fundamental changes allowed a new way of life for humans, meat was no longer a way to survive, now it was more about a way of enjoying good food. Eating meat has its benefits, although, it is more about a convenient and tasteful food choice in today's society. Red meat contributes with many important nutrients to the diet, and it is not only a great source of high-quality protein, as most people know. Important micronutrients, including B-vitamins (especially B_{12}), zinc, heme-iron and essential fatty acids in the meat contributes to a diet for optimal health as well. The well-known debate regarding the eventual impact of red- and processed meats on the human health, have unfortunately resulted in shifting the focus from meat as a great source of nutrients to a cause for poor health and diseases. Studies have shown that consumption of red meat and processed meat over a long period of time is likely associated with an increased risk of colorectal cancer. This is often explained by the possibility that carcinogenic heterocyclic aromatic amines, polycyclic aromatic hydrocarbons and N-nitroso compounds are produced during cooking and processing of meat (IARC Working Group on the Evaluation of Carcinogenic Risks to Humans and International Agency for Research on Cancer, 2018). A decreased intake of red- and processed meat should therefore be better from a health point of view but the highly digestible

proteins with all the essential amino acids that we need, will be difficult to obtain from other food sources. Red meat contains about 20-25g of protein per 100g meat, of these 20-25g protein 94 percent are digestible. This can be compared with legumes, such as beans, lentils and peas, which have a relative high protein content. They have a protein content in the rage of 4,5-9g per 100g canned product (Gard et al., 2010) and with a digestibility of 75 percent (Hoffman and Falvo, 2004). To eat or not to eat meat is a complex question from a health perspective. As with many other types of food it is a question about how much and how often. To see meat as a luxury food source instead of every-day protein can be one option. Over consumption of meat might not be good for anyone, and to eat a varied diet with both vegetables and high-quality meat, can make consumers appreciate the food on the plate more. This could result in a more conscious choice next time they buy meat.

2.2 Meat and sustainability

Do we need to stop eat meat to solve the climate crisis? The documentary "Cowspiracy" on the media service provider Netflix changed the world's opinion about meat and animal husbandry over night without any criticism and no scientific evidence. Animal husbandry contributes to much more than we can imagine, it is not only a greenhouse gas emission source as described in the documentary. The fact that livestock farming is a serious source of greenhouse gas emissions, nutrient input and pesticide use is however something that we cannot get away from (Lööv et al., 2013). One fifth of the world's total greenhouse gas emissions comes from humans farming livestock and it is a problem associated with significant climate impact. The three biggest contributing emission factors from food production are: Methane from ruminant's digestion, nitrous oxide from feed production and carbon dioxide from deforestation. At the first thought it sounds like it would be better if we all became vegetarians, but the meat question is much more complex than that.

Cattles in Sweden need, according to law, between 60-120 days outdoor grazing each year (Jordbruksverket, 2019b). This contributes to not only a good welfare for the cattle but also a great source to carbon sinks in the grasslands (Lööv et al., 2013). Carbon dioxide from the atmosphere are with the help of photosynthesis stored as carbon in plants on earth. Grasslands used for animal husbandry works therefore like an enormous carbon sink that help regenerate the overflow of carbon dioxide in the atmosphere. The large areas used for grazing are often areas that cannot be used

for other cultivation. To use these areas are a perfect opportunity not to only draw carbon dioxide down from the atmosphere but also to maintain or increase the biodiversity and open landscapes that are needed. Biodiversity have a great importance on agriculture and especially the variety of insects that are contributing to pollination and works as natural pest-fighters. The contribution to a more sustainable world during the other 245-305 days over the year, when the cattle are held inside are mainly one factor: manure. Production of synthesized fertilizers is one huge source to greenhouse gas emissions due to the large amounts of fossil fuel that needs to be used. To instead use manure, a by-product from farming cattle, is one option to minimize the emissions. These valuable feces can also be used as renewable fuel with the help of anaerobic digester that will convert the manure into biogas.

Another by-product is all culled dairy cows that becomes meat after ending their milk production. Over 50 percent of all slaughtered cattle's in Sweden are former dairy cows (Svenskt Kött, (n.d.)b). It has been shown that emissions from dairy cattle production have approximately 50 percent less carbon dioxide equivalents per kilo meat compared to specialized beef cattle production (Lööv et al., 2013). This contributes to Sweden's low level of greenhouse gas emissions in the cattle production compared to other parts of the world. If we compare Swedish beef production with corresponding production in EU, the greenhouse gas emissions are almost 25 percent lower per kilo beef in Sweden (Svenskt Kött, (n.d.)c). The Swedish cattle production is at the forefront regarding climate impact compared to other parts of the world but as with everything else, it can be improved to maintain an even better status.

2.3 Meat quality

Meat quality can be divided into six different fractions: technological, sensory, yield and gross composition, toxicological/hygienic, nutritional and ethical quality (Warriss, 2000). This thesis focuses on the technological and sensory aspects of meat quality to be able to answer the objectives of the study.

2.4 Meat quality from a sensory aspect

In the year of 2004, Stone and Sidel came up with a definition for sensory evaluation – "A scientific method used to evoke, measure, analyze, and interpret those responses to products as perceived through the senses of smell, touch, taste, and hearing" (Lawless and Heymann, 2010). Sensory analysis is therefore a method used to evaluate products of interest to maintain more information based on the human senses.

2.4.1 The human senses

Humans have always relied on their senses. A bitter mushroom or the smell of smoke helped you detect danger, thanks to your taste and smell. Nowadays we still use our senses in important ways but in a quite different way. The way we perceive a piece of food, a smell or a feeling when we touch something have a great impact on our memory, wellbeing and experience. Our taste is no longer helping us to avoid poisonous mushrooms but in many other ways.

Taste buds are small layered balls in clusters with 30-50 modified epithelial cells that can be found on the tongue (Lawless and Heymann, 2010). These small sense organs contain receptors that represents our sense of taste. When we are eating a piece of food, saliva and the food substance get mixed together. After processing the food in our mouth, the mixture reaches a pore at the top of the taste bud. Each taste bud and cell have contact with sensory nerves that sends the taste signals to a higher processing center in the brain which make us perceive the taste as either sweet, sour, salt, bitter or umami.

Our sense of smell works quite different compared to our sense of taste. We can find nerve cells in the receptors that are located in the epithelium in the olfactory region, which is a part of the nasal cavity (Lawless and Heymann, 2010). These cells are in many ways different compared to the mouths modified epithelial cells. This olfactory region is located far back in our nose, which makes them protected, but the location also reduces the amount of airborne substances that we can detect. Our nose has been developed to compensate this and with several million receptors in each nasal cavity it has enhanced its sensitivity. Cilias can be found on the receptors, these cilias spreads into the mucus layer with a function to increase the surface area of the cells even more. The receptors are more exposed to chemical substances that are floating around in our noses with this adjustment. When a volatile substance reaches our nose, the substance activates the receptors which results in an activation

of multiple enzymes. This chain reaction of enzymes ends up in a neural signal to several regions in the brain which detect the odour and make us conscious about it.

When we are talking about taste in daily life, we are not only talking about the five different basic tastes sweet, sour, salt, bitter and umami. Red wine for example can have the taste of red fruits, an oaky note or have flavours of minerals. Taste that we can register in our mouth are not these complex "tastes", all these complex experiences that we distinguish as tastes are actually something that is called "retronasal smell" (Lawless and Heymann, 2010). The diversity of all flavours we identify comes from the airborne volatile molecules we register by the receptors in our nose. Most of our food flavours are actually mediated by smell. The taste from a lemon for example are only defined by sour, sweet and bitter, the other flavours are the terpene aroma compounds that reaches the nasal cavity from the mouth via the retronasal direction. It can also be explained as an internal smelling. This can be demonstrated when eating something with your nostrils shut. The only taste you can distinguish now are sweet, sour, salt, bitter and umami. The retronasal passage to the receptors in the nose is blocked and right after opening your nostrils again you can feel the retronasal smell. People tend to talk about smells as "tastes" and this has been used in sensory marketing to name products in a more describing way.

2.4.2 Palatability

Texture, juiciness and flavour/odour are three different characteristics that cover palatability or eating quality of meat (Warriss, 2000). The most important characteristic of these three are texture and this gives us the answer why Tender Loin (see figure 1) is the most expensive and coveted cut of beef. Both Strip Loin and Rib Eye steaks are known for its deep flavour and juiciness due to a high content of intramuscular fat, and despite this, both these cuts are less expensive and coveted as a result of a more tough meat compared to the fillet. The perception of tenderness is although not only a result of the structure of the meat. It has been shown that tenderness and juiciness are interrelated. Two samples with the same texture measured with an instrumental shear test but with different juiciness appears to have different perception of tenderness. The meat with the highest rate of juiciness are also the one that appears to be the most tender one. This is an important aspect when talking about palatability for meat from older animals. Cattle with a higher slaughter age tend to have a tougher meat structure but also a higher grade of intramuscular fat that effect the juiciness (Nishimura, 2010). The knowledge of these two combinations can help the tougher meat to be perceived as more tender.

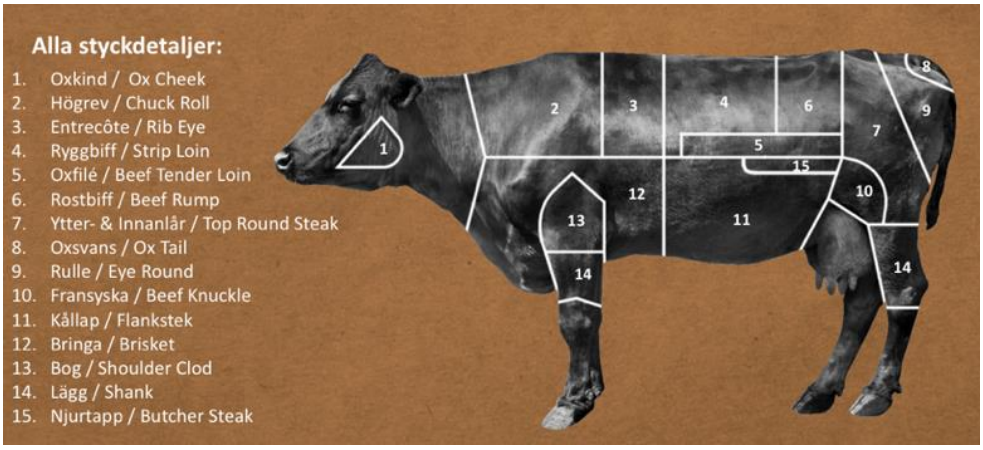

Figure 1 Names and placing of the most used cuts of beef. (HKScan. (2019). Nötakademin)

2.5 Meat quality from a technological aspect

The functional properties of meat such as pH, colour, water-holding capacity (WHC) and texture have a huge impact on the final meat product. Factors that are affected is not just the final eating quality of the meat, toxicological/hygienic and storage properties are also affected. Functional properties are influenced by a multiple different factor such as pre-slaughter treatment (such as transport, time at the abattoir before slaughter etc.), feeding, genetics, breed, slaughter method, treatment and stunning, chilling and storage conditions (Olsson, 2004). There is a large variation in meat quality due to these factors and animals of the same sex, breed and from the same environment can differ a lot in the quality aspects. A way to measure and obtain a general quality check of the meat can be done by measuring pH, WHC, colour, degree of marbling and texture.

2.5.1 pH

The first stage of cattle slaughter in Sweden is pre-slaughter stunning (Jordbruksverket, 2019c). This is done either with a captive bolt pistol, rifle or shot gun in the forehead of the animal. The cattle are in this stage unconscious before the second step of the slaughter starts, the bleeding. The bleeding process is done by opening both the carotid arteries in the animal or the common blood vessels from which these veins originate. It is in the bleeding stage the animal enters post-mortem and is counted as a carcass instead of a living animal. It is with multiple different reactions the muscle in the carcass starts to convert to meat, one of the most important responses to one of the reactions for this conversion is the pH decrease.

The pH decrease starts right after the blood circulatory system stops (Bendall, 1951; Olsson, 2004). The supply of glucose and oxygen to the muscle in the animal ceases. This results in an anaerobic metabolism in the carcass. Due to the lack of oxygen supply oxidative decarboxylation and phosphorylation no longer operate, adenosine triphosphate (ATP) can now only be regenerated through breakdown of glycogen via glycolysis. The remaining glycogen converts to lactic acid and the muscle gradually acidifies. This results in a pH decrease. The initial concentrations of creatine phosphate and glycogen are affecting the pH decrease, and these two factors are determined by the conditions of the animal prior to and during stunning. Stress and energy expenditures for the animal are affecting the levels of creatine phosphate and glycogen significant (Węglarz, 2010). If the animals are stressed before and during slaughter, a depletion of muscle glycogen reserves occur and the lactic acid production in the post-mortem muscle becomes deficient. A muscle with a ultimate higher pH results in a meat with different colour, structure, tenderness and taste. This type of meat change is called DFD (Dark-Firm-Dry) and is characterized by a dark colour with a firm and dry texture. DFD meat with decreased quality properties has an ultimate pH over 5.8 and "normal" meat of high quality has a pH around 5.5 but can vary between muscles. Except the properties mentioned above, DFD meat also has a high spoilage potential due to its higher pH. This results in a meat that is not possible to be further processed to other meat products or vacuum packaged for storage. A big financial loss for the slaughter- and meat company is therefore expected and should be avoided.

2.5.2 Tenderness

One of the most important quality factors linked to eating experience for consumers is how tender the meat is (Nishimura, 2010). In a purchasing habit study with 120 panelists, over 50 percent of the participants rated tenderness as one of the most crucial palatability traits (Corbin et al., 2015) The tenderness was close followed by the eating quality characteristics flavour and juiciness. Texture and tenderness of meat depends on the skeletal muscles structure and composition (Nishimura, 2010). The skeletal muscle are composed of muscle fibers, which contain tubular myofibrils and surrounded by connective tissues. It is the structural change of the myofibrils during the post-mortem rigor development, that change and reduce the tenderness of the meat. As mentioned, texture and tenderness are also affected by intramuscular connective tissues (IMCT), the amount, structure and composition vary extremely between species, muscles, breeds and age of the animal. The post-mortem difference between myofibrils and intramuscular connective tissue are

IMCTs immutability during ageing. Due to this, IMCT are often counted as a "background toughness" that can not be affected.

One of the main tenderness factors has proven to be the age of the animal (Nishimura, 2010). A tougher meat is linked to older animals, this is due to an increased amount of collagen crosslinks in the muscles during increasing age of the animal. The collagen crosslinks are playing a big role in the mechanical properties of the intramuscular connective tissues and are resulting in a more tough meat. Older animals also tend to have a higher amount of marbling adipose tissue which have shown to disorganize and weaken the structure of intramuscular connective tissues and contributing to a more tender meat. Tenderness of meat and marbling levels have therefore been proven to have a positive correlation. It seems that cattle species with high marbling grade genes do not therefore automatically have a more tough meat with increasing age.

2.5.3 Marbling

Intramuscular adipose tissue, or how most people know it: fat marbling, are the most important adipose tissue depot from an eating quality point of view (Smith and Johnson, 2016). It can be seen in the muscle as a marble pattern of thin, small white fat streaks and flecks (Miller, 2002; Friman, 2019). The degree of marbling is depending on the amount and how well and evenly spread these streaks are over the surface of the meat. The intramuscular adipose tissue in most cattle are located within the connective tissues between muscle fiber bundles and consists of clusters of individual cells (adipocytes) (Smith and Johnson, 2016). It has also been shown that in the longissimus muscle from cattle with the highest quality grade in Japan (Japanese Black A5 cattle) this type of cells have been located within muscle bundles, not just between. The amount of intramuscular lipids has a high impact on the quality on beef. Marbled beef has been highly valued in Korea, Japan and in the U.S. for almost a century and consumers in other parts of the world are now also starting to understand the value of the fat. Smith and Johnson (2016) describes in their study that an increased fat percentage is accompanied with a proportion decrease of saturated fatty acids (SFA) and trans-fatty acids. This is corresponding to an increase in oleic acid (18:1 n-9) and other monounsaturated fatty acids (MUFA) which has been shown to have a direct effect on healthfulness and palatability of beef. It has also been shown that a higher amount of oleic acid and other monounsaturated fatty acids have been improving the overall palatability of beef. The increase of MUFA in beef may correspond to a higher fat softness which

could provide a juicier and more fluid mouthfeel. This is something most people perceive as more desirable when they are eating a piece of beef.

The most slaughterhouses in Europe are today evaluating and grading the carcass in a system called EUROP (Council of the European Union, 2007). Grading of the carcasses is performed with highly educated and trained graders that are inspected by the Swedish Board of Agriculture regularly. This EUROP system is based on the quality of the meat in conformation and fatness aspects and are mainly focusing on the fat content and muscle confirmation rather than the intramuscular adipose tissue of different cuts. The system is designed to give the producer a fair and equal payment for his animals, although it has some drawbacks. There are 15 different scores that specify the fat content of the carcass, -1 are the lowest value and 5+ are the highest (Svenskt Kött, 2019a). A carcass with too much subcutaneous fat results in an overall lower value of the carcass. This is due to the high amount of excess fat that needs to be removed before the butcher can handle the carcass properly without risking working with to heavy lifts. The problem is that studies have shown that the relationship between subcutaneous fat and marbling has a positive correlation (Maddock, 2013). The higher the amount of subcutaneous fat, the higher the grade of marbling. This results in less payment for those producers who breed for a higher eating quality with more marbled beef cuts.

Slaughter companies in Sweden are not only grading the carcass according the EUROP system. An fat marbling system called “Swedish system for quality classification of beef” developed by “Matlandet Sverige” is often used to grade the fat marbling from different animals (Stenberg, 2013). The classes of marbling specifies the carcass fat distribution and is a tool for the employees to grade and classify the cut from the carcass correctly. This system contains five different grades from 1 to 5 where 1 is the lowest marbling score and 5 is the highest (see figure 2). One represents a cut with no marbling, two “small”, three “modest”, four “moderate” and five “slightly abundant” in the USDA-scale.

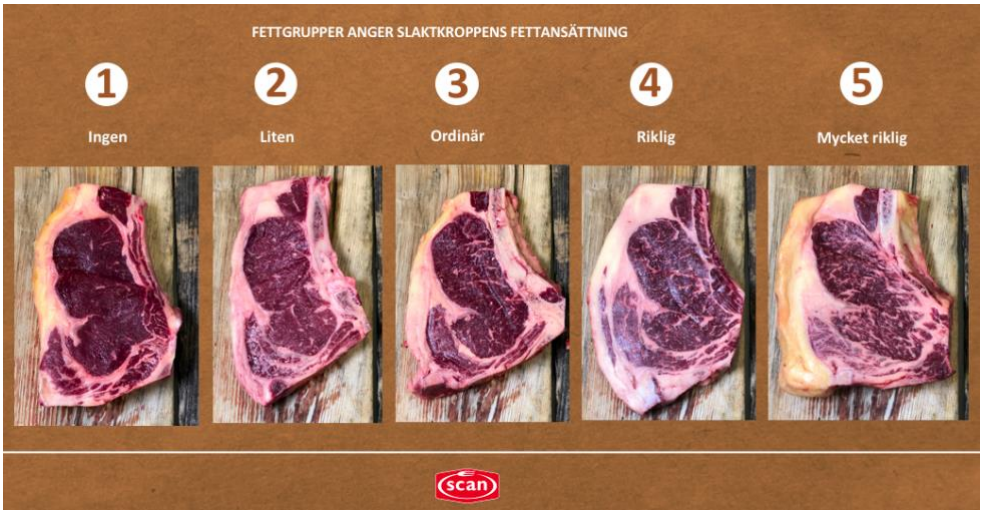

Figure 2 HKScans picture of the marbling grading system from 1 to 5, were 5 have the highest amount of intramuscular adipose tissue and 1 the lowest. (Benny Granqvist, HKScan. (2019). Nötakademin)

2.5.4 Water-holding capacity

Roughly 75 percent of lean meat is water (Warriss, 2000). Most of this water is held within the muscle of the animal. The water is stored in the space between thick and thin filaments of the myofibrils and is held there by capillary and chemical forces. After slaughter, the development of rigor mortis starts and this make the muscles shrink, which result in water loss from the muscle fibers out to the extracellular space. If the meat is cut post-rigor mortis a part of this extracellular water will be lost as "drip" which is a solution of water and sarcoplasmic proteins. Muscle acidification will also increase the amount of drip loss. Drip formation has a strong connection to water-holding capacity (WHC). Meat with a low WHC are correlated with more drip and vice versa. A definition of WHC from Hamm, 1986 is "The ability of meat to hold its own or added water during the application of any force". We can with this definition make a conclusion that WHC and the water in the meat have a strong correlation. Two other properties that have a strong correlation are juiciness and the amount of water in meat. Robyn D. Warner describes juiciness as a unique subjective property of meat in the chapter "The Eating Quality of Meat" from R. A. Lawrie and David Ledwardts book "Lawrie's Meat Science" (Lawrie and Ledward, 2014). She describes that the subjective property of juiciness often can be referred to dry (lack of juiciness) meat or moist (juicy) meat. Juiciness are therefore an indirect way to also measure WHC. Meat juiciness is the feeling and impression of moisture when the meat is chewed. This can be measured and determined subjectively with sensory panels or consumers rather than objectively with an established measuring method. The subjective way to measure juiciness is

divided into two components. The first is the impression of meat juices and the second is related to the impression of wetness caused by the fat content of the meat that are stimulating the effect of salivary flow.

2.5.5 Colour

The consumer's decision of a purchase is depending on a number of different factors, the visual acceptability of the meat is one of the most important ones (Carpenter et al., 2001). Water-holding capacity is a crucial property of the appearance of meat, but another very important factor is the colour of the meat. In Mancini and Hunts study from 2005 it has been shown that the quality factor that are influencing purchasing decisions the most is colour (Mancini and Hunt, 2005). The bright red colour of oxymyoglobin relates to wholesomeness and freshness while the gloomy brown colour of metmyoglobin is more undesirable (Brugiapaglia and Destefanis, 2009). The colour of meat is something that is changing depending on the environment around the cut and the initial concentrations of myoglobin and to some extent hemoglobin (Warriss, 2000). The muscles pigment myoglobin can appear in three different chemical states that have a major impact on the colour of the meat. These three forms of pigment are myoglobin (Mb), oxymyoglobin (MbO_2) and metmyoglobin (metMb) (see figure 3). To form oxymyoglobin from myoglobin an oxygen molecule (O_2) need to connect with myoglobin. This is what we see happen in a freshly cut meat surface, the purple myoglobin pigment is changing to its oxygenated form and form a bright red oxymyoglobin colour. Myoglobin and oxymyoglobin can from this state oxidize their iron from the ferrous state (Fe^{2+}) to ferric iron (Fe^{3+}) and thereby metmyoglobin is formed. This grey-brown pigment state only occurs in a limited extent in meat that has been aged for a long time post-mortem. One way to control colour changes is to use specific atmospheres with high concentrations of oxygen, often combined with carbon dioxide and nitrogen during storing of meat. The gases inhibit colour changes, prevent undesirable bacterial growth which extends the best before date and help the package to maintain a good environment for the meat.

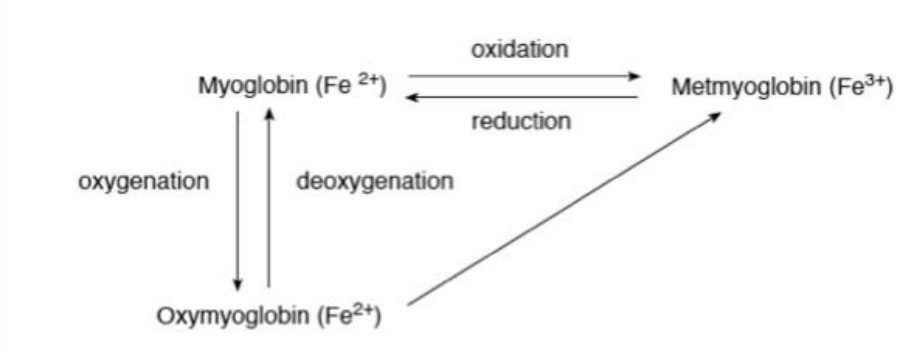

Figure 3 The relationship between myoglobin, oxymyoglobin and metmyoglobin. (Warriss, P.D. Meat Science: An Introductory Text. (2000). s. 170)

Meat colour can be measured in several different ways, which can be divided in either subjectively or objectively. The subjective way of measuring colour is difficult because of the individuals own perception of the meat colour. One way to facilitate this is by using colour cards to compare the piece of meat with the cards (Warriss, 2000). The objective way of measuring colour is a more consistent and accurate way of evaluating the meat colour. As mentioned above one factor that are influences the colour of the meat is the myoglobin pigment, content and chemical form. Another factor that influence the colour is the degree of protein denaturation in the muscle fibers after rigor mortis. The change in proteins after rigor mortis due to pH changes from the normal pH 7 influence light scattering. An increased pH drop increases the degree of protein denaturation which can be seen in meat as a more pale and opaque colour, compared to the muscle in a living animal that are more dark and translucent. One way to measure this reflectance objectively are with a colour meter. This instrument is measuring the colour reflectance/absorbance in the area between 400 – 700 nm (Konica Minolta, 2018). The colour space used in Minolta are the CIE 1976 L*a*b* colour space who also is known as CIELAB. The different letters in L*, a* and b* are referring to colours or lightness in different positions (see figure 4). L* are representing the lightness or darkness of the colour where 0 yields black and 100 indicates a white diffuse colour. a* are defining the position between the colours green and red/magneta where -a* indicates green and +a* indicates red/magneta. b* are defining the position between the colours blue and yellow where -b* indicates blue and +b* indicates yellow. The values for a* and b* can differ between -60 and +60.

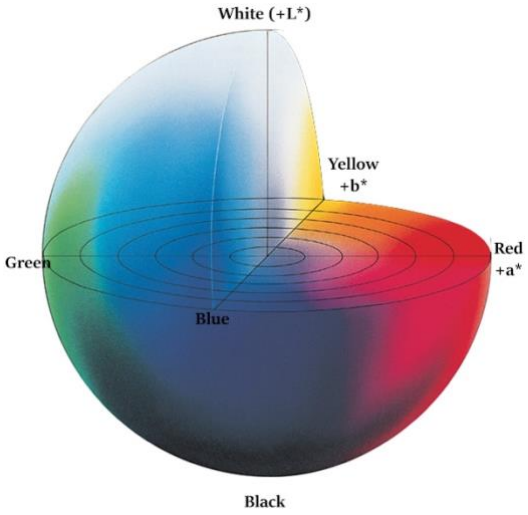

Figure 4 CIELAB colour globe is describing the relationships between L, a* and b* colour space. (KonicaMinolta (2019))*

2.6 Sensory and sensory methods

Sensory is a category within science that teaches about the experience from our five senses, touch, smell, taste, hearing and sight (Öström and Westling, 2015). It is a way to put experience into words. The science within sensory for foodstuff are widespread and the interest of learning more about how we interpret food products are enormous. One way to evaluate the sensory behind the products are with sensory methods and evaluations.

The definition of sensory evaluation is "a set of techniques for accurate measurement of human responses to foods and minimizes the potentially biasing effects of brand identity and other information influences on consumer perception" according to Lawless and Heymann (2010). The aim of evaluation is to isolate sensory properties of foods to maintain important information that could be valuable for food scientists, product developers and other food businesses (Lawless and Heymann, 2010).

2.6.1 Descriptive analysis

A sensory descriptive analysis allows the researcher to obtain descriptions of the chosen product that help identify and describe the effects of underlying ingredients, processes and sensory attributes that are valuable for the product (Lawless and Heymann, 2010). The description of the product would therefore be in terms of the

perceived sensory attributes. A descriptive analysis can be formed in many ways, but it is common to use 8 to 12 trained panelists that are using a quantitative scale for intensity that measures their hedonic response to the product. This type of sensory method is generally useful when the sensory scientist would like to have a detailed description of the sensory attributes of a product. It can also be useful if the scientist would like to compare sensory differences between several products. A descriptive analysis methods require many participants that needs to be trained and calibrated towards the product. This requires a lot of time and resources that can be expensive. A way to minimize these costs have been to produce new descriptive methods that do not require as much as the original methods. One of these new created descriptive analyses are the CATA method.

2.6.2 CATA method

CATA stands for "Catch-all-that-apply" and are a quite new consumer-based method that were developed to easily describe and evaluate products (Ares and Jaeger, 2015). The method is made of a question format that the respondents should select words and phrases from that they consider appropriate for the product/s. It can be both sensory and non-sensory terms. A smoothie for example can be evaluated with a CATA questioner that contains both questions about "blueberry flavour" and "If it feels like a healthy option". This is a way to describe a product entirety, not only by describing its flavour, appearance, texture and odor properties.

CATA have been used in especially marketing research to increase information from the consumers experience of the product (Ares and Jaeger, 2015). Information about the sensory characteristics of the product that is obtained with this method is similar compared to the use of other descriptive methods with a trained panel. The advantage with this type of method are many. With a large number of words and phrases, this type of method provides sensory characteristics that are fully described without that much effort from the participants. Selecting words and phrases is a task that requires less cognitive effort than other traditional descriptive methods. The participants are therefore often more motivated to finish the task that they have been provided with compared to other attribute-based methods that require a lot of time and thinking. This makes CATA a reliable sensory analysis despite its fast and easy methodology. Another advantage is the time (and cost) you save with a consumer panel that are not trained and calibrated for the type of product that are analyzed. By using participants that are frequent consumers of the type of product that is

analyzed is often an asset. It is valuable for the companies that manufactures the product to maintain information that comes from frequent consumers that are used to similar foods. Knowing the product can help build a trustworthy marketing that increases the sale.

2.6.3 Sensory marketing

Sensory marketing is a marketing strategy that in some way affect our senses (Swahn et al., 2011). It is a way to experience brands and products that affect our consuming behavior. Consumers are constantly searching for experiences that are memorable and unique. Using sensory marketing is one way for companies to expand and develop their business. The humans rational thinking can be influenced by a lot of impressions, not least the one that are coming from sensory responses. One way to communicate a products sensory characteristic can be with a sensory language. A sensory dictionary, lexicon or terminology for different foodstuff is valuable in many points of views, for example to develop the business. Brian Wansink, James Painter and Koert Van Ittersums study "Descriptive Menu Labels' Effect on Sales" showed that descriptive names on restaurants dishes could increase the sale with up to 27% (Wansink et al., 2001). To rename a dish from *"*Seafood filet*"* to a more descriptive name such as *"*Succulent Italian seafood filet*"* did affect the consumers whole perception of the meal.

A sensory language for beef could also be important from a communication perspective. It is important to catch the consumers attention in the store during their purchase experience. This will help the consumer to understand the quality of the product they are buying. If we take two different beef steaks for example. The first, a round steak and the second, a ribeye steak. Describing these two different steaks with a sensory language could be helpful to the consumer when they want to choose a meat that suits best for the meal they are buying it for. A juicy, tender and umami-tasting ribeye with high marbling are suited perfect for a quick barbecue while a round steak with a lot of flavour bounded into the fibers fits better in a slow cooker. Two perfect pieces of meat but with different roles in different meals. To help the consumer to choose right piece of meat for the right purpose could also make the buying experience more valuable. If consumers know that the product they are buying have the quality that they are expecting they probably are willing to spend more money (Nguyen and Gizaw, 2014). A sensory language for beef would therefore not only help the consumers to choose right cut, it would also improve the business for the slaughter- and meat companies.

3 Methods

Three different cuts of Strip Loin (*M. longissimus dorsi*) from beef were selected with different marbling grade (meat nr. 2-4, see table 1 and 2 and figure 5). These beef cuts came from three different Swedish cattle. Strip Loin from one grass-fed Swedish cattle were selected as a sensory reference to the experiment (meat nr. 1, see table 1 and 2 and figure 5). Grass-fed cattle is an animal that have been raised on semi natural grasslands for at least 50 percent during the grazing period (Naturbeteskött Sverige, 2019). The winter forage should also be based on roughage and be free from imported protein crops.

Table 1 Information and varieties of the four different meat samples.

Sample nr.	Production system	Origin	Breed	Slaughter age (months)	Type of cattle	Slaughter date
1	Conventional, grass fed	Småland	SLB	24	Steer	190925
2	Organic	Småland	SRB	28	Cow	190927
3	Conventional	Småland	SRB	45	Cow	190924
4	Conventional	Östergötland	SRB	42	Cow	190927

Table 2 Information about the conformation of the carcass, weight of the animal, feed and marbling grade were 1 is the lowest marbling grade and 5 is the highest for all four meat samples. The class column has its origin from the EUROP system where 1 is the lowest value and 15 is the highest. The fat group has also 15 classes where 1 is the lowest value with least subcutaneous fat and 15 is the highest value with most subcutaneous fat.

Sample nr.	Conformation score	Fat score	Carcass weight	Marbling grade	Feed
1	3	8	337 kg	2	Mainly roughage

2	5	11	321 kg	5	Concentrate and roughage
3	5	11	438 kg	3	Concentrate and roughage
4	8	3	303 kg	1	Concentrate and roughage

Figure 5 Picture of the four different meat samples with numbering (Sara Samuelsson, (2019)).

Meat samples were provided by HKScan, Linköping, Sweden. All four cattle were slaughtered week 39, 2019 (see table 1). About a week after slaughter, three slices of Strip Loin from each sample were sent to Uppsala, Sweden in vacuum bags for pH and colour measurement in a pilot trial and the qualitative sensory analysis (open discussion), see table 3. The remaining cuts of Strip Loin from the four samples were dry aged on bone for five more weeks until five days before the main experiment with pH and colour measurement and the quantitative analysis, CATA. The cuts were then de-boned, sliced in to 1.5 cm thick slices and vacuum packed for transport from Linköping to Stockholm, Sweden. The meat slices were stored for five days in vacuum bags in a refrigerator at 5 degrees Celsius until the day of analysis at the market research company Ipsos. The day before the analysis at Ipsos, one vacuum bag of each sample was transported to Uppsala and SLU, Swedish University of Agricultural Sciences were the technical analysis were performed.

Table 3 Overview of events for the beef samples (year 2019)

Date	Events
23 - 29/9 (w.39)	Slaughter (Linköping, Sweden)
7/10 (w.41)	Pilot analysis, pH and colour measurement (Uppsala, Sweden)
8/10 (w.41)	Sensory analysis, open discussion (Uppsala, Sweden)
24/9 – 31/10 (w.39 - w.44)	Dry ageing on bone (Linköping, Sweden)
31/10 (w.44)	De-boning, slicing and vacuum packing (Linköping, Sweden)
31/10 – 5/11 (w.44 – w.45)	Stored in refrigerator (5 degrees Celsius; Stockholm, Sweden)
5/11 (w.45)	Sensory analysis, CATA method (Stockholm, Sweden)
5/11 (w.45)	Technological analysis, pH and colour measurement (Uppsala, Sweden)

3.1 Technological characterization of meat samples

All four meat samples were submitted to technological analyses of pH and colour. Three pH measurements in each meat sample was done with a Kick Portamess® 911 pH meter (GmbH & Co. KG, Berlin, Germany). The penetration electrode from the pH meter was inserted in three small pre-cut holes to facilitate the penetration of the meat. The pH meter was calibrated at the same temperature as the samples during the analysis. Colour of the samples was measured using a Minolta® CR-300 (Konica Minolta Sensing Americas, Ramsey, USA) colour meter at three different reading points at the surface of the meat. The head of the light projection tube was placed in the most homogeneous colour area on the meat surface. Areas with high content of adipose tissue were avoided. The meat was removed from the refrigerator and vacuum bags maximum 20 minutes before the analysis. This was done to prevent oxidation and colour change due to the initiation of metmyoglobin-state. An average measurement value was calculated and obtained both from the pH- and colour measurement.

3.2 Sensory analysis

The sensory analysis was performed with two different methods, one qualitative (open discussion) and one quantitative (Check-all-that-apply (CATA)). The qualitative method was performed to generate attributes to the quantitative. The process of generating attributes for flavour, appearance and texture for the CATA method used in this study was performed through a small open sensory discussion with an untrained panel. Some of the attributes generated in the open discussion had its origin from the "Wine Aroma Wheel" (Noble et al., 1984). A "terminology wheel" used to describe and group together aroma words that could be used as descriptive terms for wine tasting. This aroma wheel is not only useful when describing wine. The describing terms in the wheel can be used to express several different foodstuffs, including meat products. With these words as a "starting point" an untrained panel of five persons and a panel leader had an open discussion to generate the attributes in table 13, 14 and 15 in appendix. The open discussion that generated these attributes followed the method used in Ares, Giménez, Barreiro and Gámbaros study from 2010, with slight modifications (Ares et al., 2010). The best describing attributes that could fully describe the meat samples were chosen to the final CATA questions found in table 4. This table consists of 24 flavour-, 14 appearance- and 9 texture attributes that were used as final CATA questions during the analysis.

The respondents recruited for the quantitative sensory analysis, CATA consisted of 30 untrained participants. This panel consisted of 50 percent women and 50 percent men with the age between 20 – 65. The market research company Ipsos, who also performed the analysis recruited the respondents from their already established consumer panel. All participants were frequent consumers (at least 2-3 times a month) of beef in the form of Strip Loin or another type of similar beef cut. The respondents were also consumers that prefer their meat cooked "medium" and they stand for at least 50 percent of the households purchases of food.

The CATA method was performed during one day at Ipsos head office in Stockholm. The room used for sensory analysis was built according to ISO-standard for sensory analysis. The 30 respondents were divided in to two groups with 60 minutes each for the sensory analysis. The analysis was divided in to two parts, the

first one consisted of appearance evaluation and the second one evaluation of flavour and texture. The appearance evaluation was performed with one slice Strip Loin from each meat sample. The meat was removed from the refrigerator and vacuum bags maximum 20 minutes before the analysis. The appearance analysis started with the correspondents looking at each meat sample on white porcelain plates and evaluate them with the appearance CATA questions in mind. The answering of the CATA questions for each correspondent was done using the software Fizz (Biosystem, Couternon, France) on a computer. The CATA questions in Fizz were applied with forced choice and the respondents had to choose either "yes" or "no"

The meat samples for flavour and texture sensory characterization were placed in room temperature three hours before the analysis. All meat samples were dried on the surface before frying to remove excess meat fluid. Each slice was then dry salted with 1,5 percent salt of the total weight of each sample. All four meat samples were placed in four different frying pans with 1 tablespoon of hot-pressed rapeseed oil. The frying pans had a temperature of 180 degrees Celsius before the cooking started. When the meat reached an inner temperature of 35 degrees Celsius the temperature of the frying pan was decreased to 120 degrees Celsius. The meat was turned around four times during the cooking to avoid burning. The meat samples were done when the inner temperature reached 58 degrees Celsius (medium cooked). All meat samples rested for 7 minutes after frying before each slice were sliced up in six tasting samples for the correspondents and placed on white porcelain plates. Each correspondent was provided with one meat sample at a time for flavour and texture evaluation in the software Fizz with the CATA questions for flavour and texture.

The meat samples were coded with a random three-digit code during the sensory analysis. This was done to avoid bias and to provide a balanced sample order to the extent possible to bypass artifacts.

Table 4 Check-All-That-Apply (CATA) attributes for Strip Loin from beef. Flavour and texture were evaluated by tasting and appearance by looking at the samples.

Flavour	**Appearance**	**Texture**
Intense meaty	Dry	Dry
Moderate meaty	Moist	Juicy
Bland meaty	Light red	Tough
Bitter	Clear red	Tender
Sour	Dark red	Coarse
Umami	Purpleish-red	Firm
Mineral	Brownish-red	Soft
Game	Grayish-red	Dense fibre structure
Forest	Poorly marbled	Porous fibre structure
Wood	Moderate marbled	
Grassy	Richly marbled	
Herbal	Fibery	
Floral	Smooth	
Unpasteurized dairy product	Homogenous colour	
Milky		
Nutty		
Buttery		
Oily		
Pepper		
Caramelized		
Oxidized		
Mature		
Mellow		
Off-flavour		

3.3 Statistical analyses

3.3.1 Statistical analyses for pH- and colour measuring

A significance test was done for the pH measurement to all samples against each other. The same test was performed to all colour measurements. A two tailed t-test was performed to evaluate the differences between the samples. The significance level was defined to 5% (0.05). A PCA plot was made to see if there were any correlations between the colour samples.

3.3.2 Statistical analyses for sensory characterization

A significance test was applied to all samples against each other. Ideal was also included for those questions where it was possible. A two-tailed t-test for the attributes was performed to evaluate the differences between the samples. The significance level was defined to 5% (0.05).

The result from the overall liking was analyzed by calculating a mean value for each sample and using a two-tailed t-test for evaluating the differences between the mean values. The significance level was defined to 5% (0.05).

A crosstable was made with the association level per sample + ideal.

4 Result

The interval for the pH values from all four meat samples ranged between 5.67 and 5.73. All four values are presented in Table 5. Meat sample nr. 3 had the lowest value of 5.67 and meat sample nr. 4 had the highest value of 5.73. The only samples that showed a statistically significant difference between them were meat sample 3 and 4. As seen under "significance" in table 5, there was no overall statistical difference between the samples.

Table 5 pH mean value from meat sample 1, 2, 3 and 4. Overall p-value can be seen under "Significance".

	Meat 1	**Meat 2**	**Meat 3**	**Meat 4**	**Significance**
pH	5.69^{ab}	5.70^{ab}	5.67^{b}	5.73^{a}	0.11

a-b superscript with different letters in same row differ significantly (P<0.05).

The results from the colour measurements can be found in Table 6. The L*-values ranged between 31.51 and 34.78 were meat sample 1 had the lowest value and meat sample nr. 3 had the highest value. The a*-values ranged between 13.71 and 18.57 were meat sample nr. 1 had the lowest value and meat sample nr. 2 hade the highest value. The b*-values ranged between 16.31 and 20.85 where meat sample nr. 1 had the lowest value and meat sample nr. 2 had the highest value. The overall p-value under "significance" in table 6 showed that there was a statistical difference between all samples and L*, a* and b*.

Table 6 L, a and b mean values for meat sample 1, 2, 3 and 4 from colour reflectance/absorbance measurements with Minolta® CR-300 colour meter. Overall p-value can be seen under "Significance".

	Meat 1	**Meat 2**	**Meat 3**	**Meat 4**	**Significance**
L*	31.51$_a$	33.71$_b$	34.78$_b$	32.22$_a$	0.0007
a*	13.72$_a$	18.57$_b$	15.68$_c$	17.50$_d$	<0.0001
b*	16.31$_a$	20.85$_b$	19.60$_c$	19.56$_c$	<0.0001

a-d superscript with different letters in same row differ significantly (P<0.05).

A PCA plot for colour reflectance/absorbance measurements is presented in Figure 6. Meat sample nr. 2 and 4 had more similarities and had a higher value towards red/magneta colour than 3 and 1. Meat sample nr. 3 had the highest value towards white and was not that similar in colour compared to meat sample 1, 2 and 4. Meat sample nr. 1 is the one that had the darkest colour according to the values obtained from the reflectance/absorbance measurements with Minolta. Meat sample nr. 1 was also the sample that was most different compared to the three other samples.

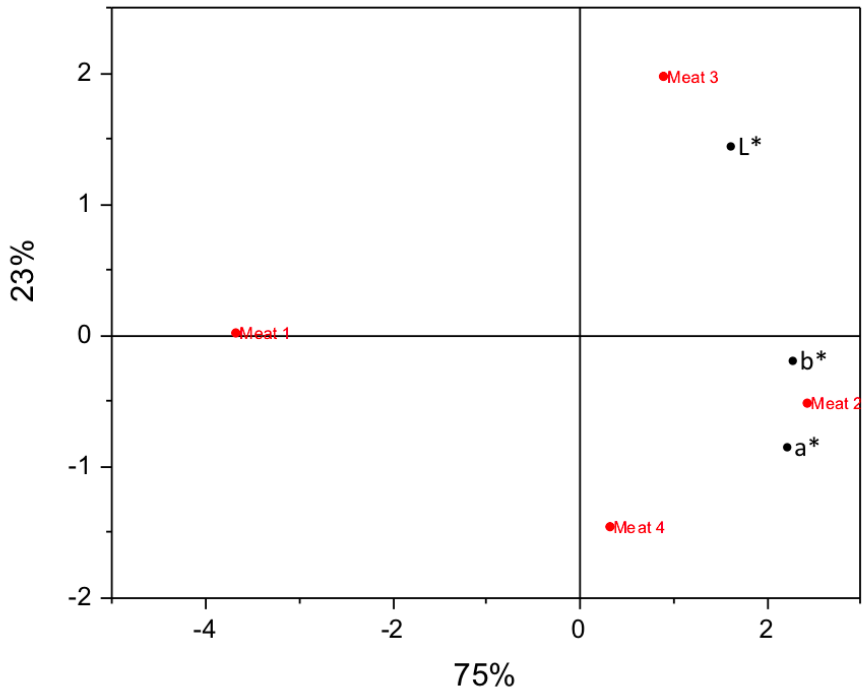

Figure 6 PCA plot for colour reflectance/absorbance measurements from Minolta® CR-300 colour meter.

Table 7 is showing a cross table with results from the CATA method performed with questions regarding appearance, flavour and texture. All questions can be found in appendix. The percentage in "Ideal" is how many of the 30 respondents that has been answering "yes" to the question if they would like to experience that attribute in their ideal piece of Strip Loin from beef. The percentage in meat sample 1-4 is how many of the 30 respondents that has been answering "yes" to the question if they think the attribute correspond with the experience of that meat sample.

Table 7 Result from the CATA method in the form of a cross table for all four meat samples and ideal.

	Ideal	**Meat 1**	**Meat 2**	**Meat 3**	**Meat 4**
Appearance					
Moist	73%	63%	70%	40%	63%
Dry	13%	33%	27%	47%	30%
Light red	33%	27%	20%	10%	27%
Clear red	60%	63%	57%	37%	77%
Dark red	70%	40%	47%	70%	27%
Purpleish-red	17%	7%	10%	13%	7%
Brownish-red	40%	13%	13%	30%	7%
Grayish-red	7%	7%	3%	17%	7%
Homogeneous colour	43%	67%	40%	37%	60%
Poorly marbled	37%	63%	7%	33%	67%
Moderate marbled	70%	63%	40%	67%	23%
Richly marbled	63%	10%	73%	57%	7%
Fibery	43%	47%	50%	63%	43%
Smooth	47%	83%	60%	53%	70%
Flavour					
Intense meaty	70%	33%	20%	40%	30%
Moderate meaty	57%	57%	70%	60%	57%
Bland meaty	23%	47%	47%	33%	43%
Bitter	0%	13%	7%	7%	10%

Table 7 Cont.

	Ideal	**Meat 1**	**Meat 2**	**Meat 3**	**Meat 4**
Sour	13%	47%	30%	27%	37%
Umami	63%	33%	53%	53%	30%
Mineral	53%	43%	43%	53%	57%
Gamey	70%	13%	17%	20%	23%
Forest	60%	23%	17%	23%	20%
Wood	20%	20%	20%	20%	30%
Unpasteurized dairy product	7%	10%	3%	10%	3%
Grass	43%	30%	27%	33%	7%
Herbal	63%	33%	33%	27%	27%
Floral	27%	10%	7%	10%	17%
Nutty	97%	70%	80%	73%	67%
Buttery	77%	43%	70%	53%	47%
Oily	7%	33%	40%	23%	20%
Milky	3%	17%	23%	3%	13%
Peppery	80%	17%	30%	23%	23%
Caramelized	53%	27%	40%	33%	27%
Oxidized	10%	23%	10%	17%	23%
Off-flavour	7%	33%	3%	10%	17%
Mellow	97%	43%	60%	67%	53%
Mature	87%	50%	40%	57%	50%
Texture					
Dry	3%	23%	7%	10%	23%
Juicy	100%	77%	97%	90%	67%
Tough	3%	47%	10%	27%	57%
Tender	100%	53%	90%	67%	40%
Coarse	3%	30%	17%	27%	40%

Table 7 Cont.

	Ideal	Meat 1	Meat 2	Meat 3	Meat 4
Firm	63%	87%	60%	73%	70%
Soft	67%	37%	73%	57%	37%
Dense fibre structure	43%	53%	43%	50%	73%
Porous fibre structure	67%	47%	57%	60%	27%

The result of ideal flavour of Strip Loin from beef in the sensory method, CATA are presented in figure 7. The five attributes that were the least wanted ones accordifng to the 30 respondents in the study were flavours of bitter (0%), milky (3%), unpasteurized dairy products (7%), off-flavour (7%) and oily (7%). The five attributes that were the most wanted flavour for the ideal Strip Loin were nutty (97%), mellow (97%), mature (87%), peppery (80%) and buttery (77%).

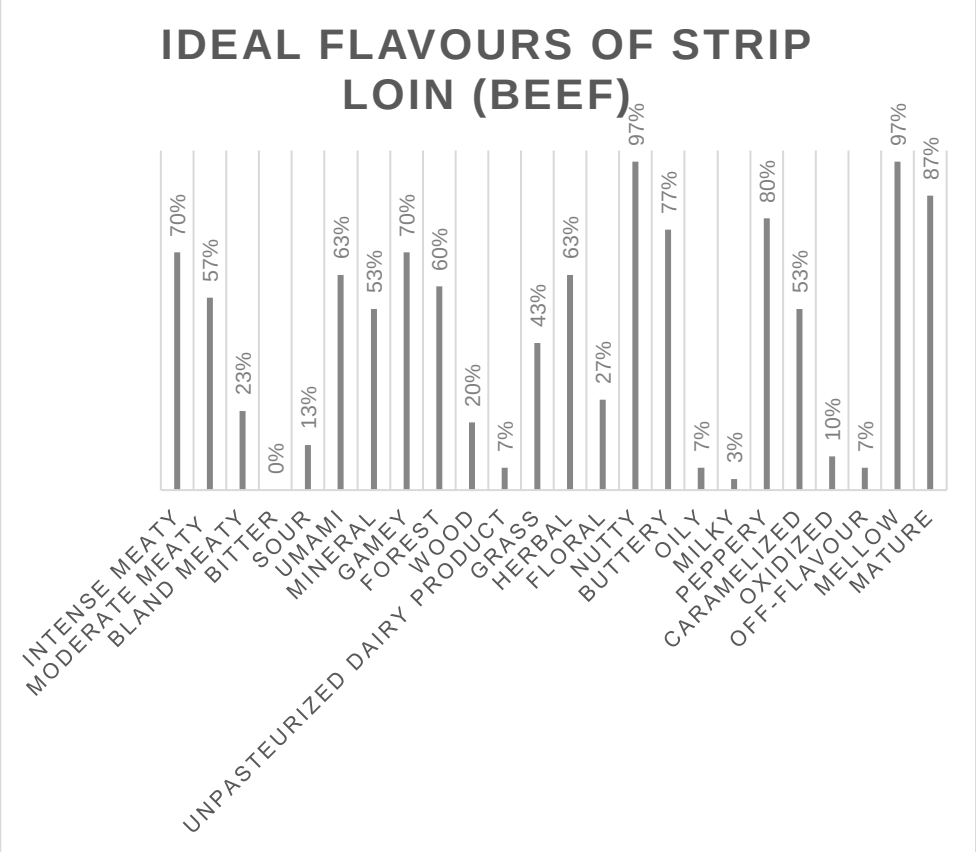

Figure 7 Describing all flavour attributes analyzed during the CATA method and the respondent's response to their ideal flavour of Strip Loin from beef. 100 percent indicates that all panelists in the study prefer that attribute as a flavour when eating Strip Loin.

A comparison between the five most wanted ideal flavour attributes of Strip Loin and the actual flavours of Strip Loin in meat sample 1, 2, 3 and 4 can be found in figure 8. All attributes except “Nutty” (ideal vs. meat 2) and “Buttery” (ideal vs. meat 2 and 3) showed a significance difference of 5% between ideal flavour and the flavour of the meat samples, which can be seen in table 8.

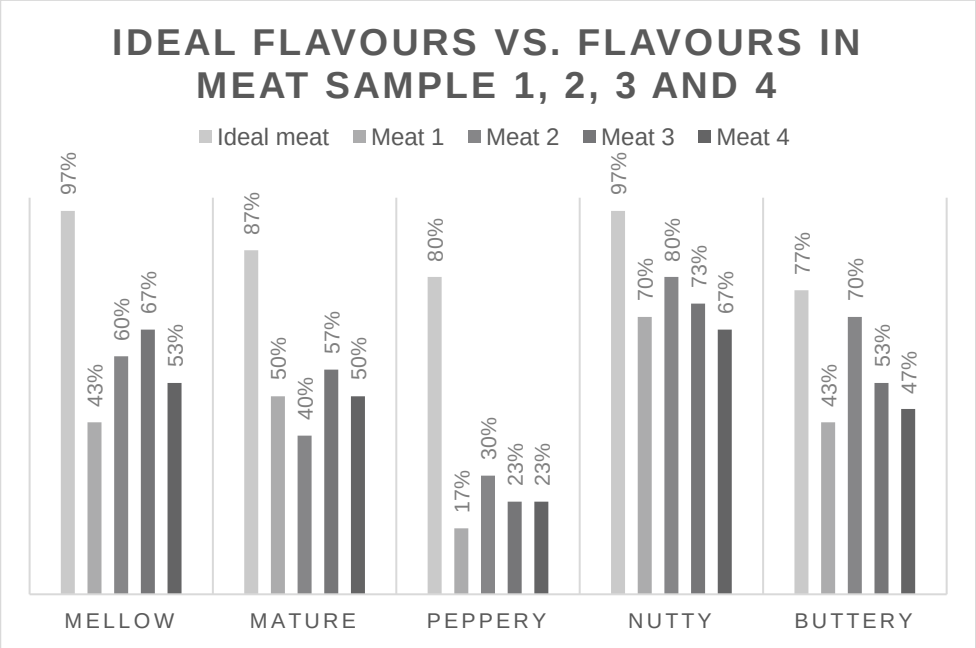

Figure 8 Describes top five ideal flavour attributes and their corresponding value from each meat sample from the CATA method.

Table 8 P-values for top five flavour attributes where ideal is compared to all four meat samples. Red and bold values indicate significant difference.

	Ideal vs. Meat 1	Ideal vs. Meat 2	Ideal vs. Meat 3	Ideal vs. Meat 4
Mellow	**0.000**	**0.002**	**0.008**	**0.000**
Mature	**0.006**	**0.000**	**0.022**	**0.006**
Peppery	**0.000**	**0.000**	**0.000**	**0.000**
Nutty	**0.015**	0.108	**0.030**	**0.008**
Buttery	**0.018**	0.770	0.104	**0.034**

A comparison between the five most wanted ideal appearance attributes of Strip Loin and the actual appearance of Strip Loin in meat sample 1, 2, 3 and 4 can be found in figure 9. The only statistical significance of 5% could be found in attribute "Moist" for ideal vs. meat 3, "Dark red" for ideal vs. meat 1 and 4, "Moderate marbled" for ideal vs. meat 2 and 4 and "Richly marbled" for ideal vs. meat 1 and 4. This can be seen in table 9.

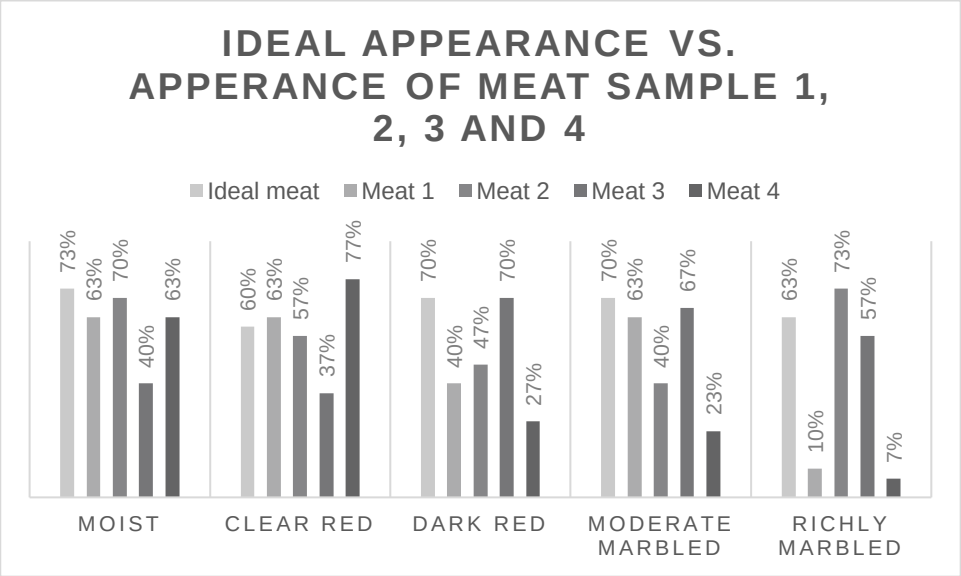

Figure 9 Describes top five ideal appearance attributes and their corresponding value from each meat sample from the CATA method.

Table 9 P-values for top five appearance attributes where ideal is compared to all four meat samples. Red and bold values indicate significant difference.

	Ideal vs. Meat 1	**Ideal vs. Meat 2**	**Ideal vs. Meat 3**	**Ideal vs. Meat 4**
Moist	0.579	1.000	**0.019**	0.579
Clear red	1.000	1.000	0.121	0.267
Dark red	**0.038**	0.116	1.000	**0.002**
Moderate marbled	0.784	**0.038**	1.000	**0.001**
Richly marbled	**0.000**	0.579	0.792	**0.000**

A comparison between the five most wanted ideal texture attributes of Strip Loin and the actual texture of Strip Loin in meat sample 1, 2, 3 and 4 can be found in figure 10. The only statistical significance of 5% could be found in attribute "Juicy" for ideal vs. meat 1 and 4, "Tender" for ideal vs. meat 1, 3 and 4, "Soft" for ideal vs. meat 1 and 4 and "Porous fiber structure" for ideal vs. meat 1 and 4. This can be seen in table 10.

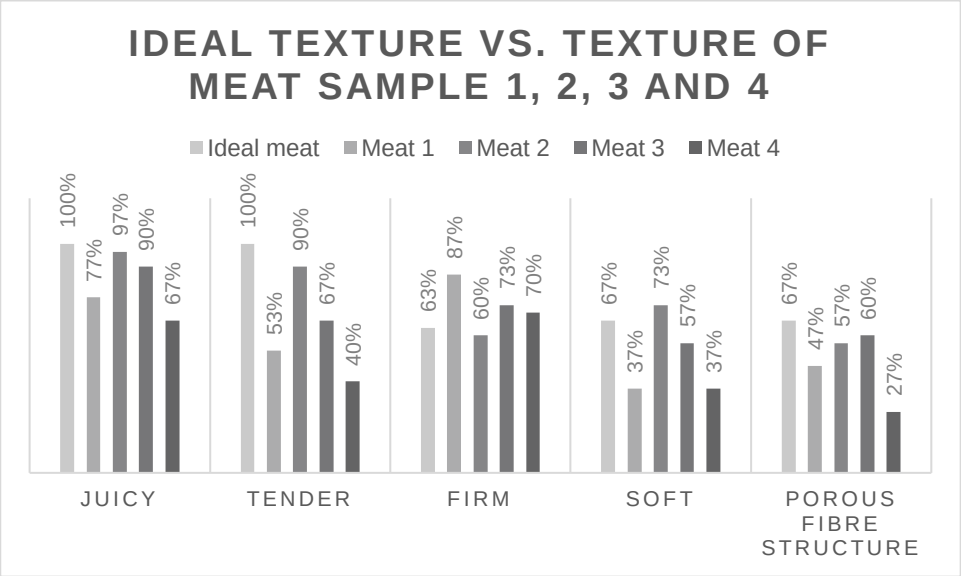

Figure 10 Describes top five ideal texture attributes and their corresponding value from each meat sample from the CATA method.

Table 10 P-values for top five texture attributes where ideal is compared to all four meat samples. Red and bold values indicate significant difference.

	Ideal vs. Meat 1	Ideal vs. Meat 2	Ideal vs. Meat 3	Ideal vs. Meat 4
Juicy	**0.016**	1.000	0.236	**0.002**
Tender	**0.000**	0.236	**0.002**	**0.000**
Firm	0.074	1.000	0.579	0.784
Soft	**0.039**	0.778	0.595	**0.039**
Porous fibre structure	0.193	0.595	0.789	**0.004**

All 30 respondents in the study got the question “how much do you like/dislike this meat sample from a scale 1 to 9, where 1 is disliking and 9 is liking” after tasting the samples. The result from that question is shown under “Acceptability” in table 11. The table shows that meat 2 had the highest acceptability and meat 4 had the lowest acceptability.

After the appearance evaluation, the respondents also got the question if they were willing to buy the meat samples, only based on appearance. This result is shown under “Willing to buy” in table 11. The table shows that meat 1 was the sample most respondents were willing to buy and meat 4 was the sample least respondents were willing to buy.

Table 11 Acceptability based on the respondents overall liking after tasting. Willing to buy based on the respondents overall liking after the visual assessment.

	Meat 1	**Meat 2**	**Meat 3**	**Meat 4**
Acceptability	63%	78%	79%	62%
Willing to buy	77%	63%	73%	57%

5 Discussion

5.1 Colour and pH

It is important to consider the fact that only one sample from each animal was investigated during the technological analysis. The analyzed slice of Strip Loin is representing the whole part of the cut on the specific animal, despite that the colour and pH could differ slightly in different parts of the muscle. The head of the light projection tube is only one cm wide, it is therefore challenging to measure the colour reflectance on the most homogeneous place on the meat with a lot of adipose tissue. The meat sample that visually looked like the darkest one, meat sample 3, according to the appearance results from attribute "Dark red" in table 7 did not appear to correlate to the result from the Minolta measurements. Meat sample 1 had the darkest colour according to the values obtained from Minolta. One explanation to this could be that the actual colour that the human eyes can perceive is not always the "correct" colour. The light and colour of the room can have a huge impact on the colour that is reflected from the meat. The amount of marbling in the meat could also affect the whole perception of the colour. This can be linked to the appearance result under the attribute "Homogeneous colour" and "Richly marbled" in table 7. The sample that looked like the darkest one (nr. 3) also had the least homogeneous colour and one of the highest marbling grades. The sample that appeared to be the darkest one according to the results from the Minolta measurements (nr. 1) had the most homogeneous colour and one of the lowest marbling grades according to the respondents. One conclusion from this study is that it is harder for the human eyes to determine the "correct" colour of the meat when it has a non-homogeneous colour and a high marbling grade.

Regarding the red colour, meat sample 2 should be closest to red/magneta after looking at the result from the Minolta measurements (see table 6). After looking at the respondents answer on the question about light-, clear- and dark red colour in table 7, meat sample 2 did not score the highest for any of these appearance attributes. The colour measurements with Minolta do therefore not correlate to the result obtained from the sensory analysis when it comes to both dark- and red colours of the samples.

The three pH measurements in each meat sample had an overall p-value that did not have any significant differences which can be seen under "Significance" in table 5. This indicates a selection of representative meat samples. All four samples had a pH value around 5,7 and as discussed in the introduction, a value around 5,5 up to 5,8 is considered "normal" and therefore do not affect the results from the sensory analysis substantially.

5.2 Sensory

The flavour attributes that over 50 percent of the respondents seemed to perceive in at least one of the four meat samples during the sensory method CATA was umami, mineral, moderate meaty, nutty, buttery, mellow and mature. These seven attributes represent the flavour part of the generated terminology of beef. The generated attributes for the texture part of the terminology was juicy, tough, tender, firm, soft, dense fiber structure and porous fiber structure. The generated attributes for appearance were a clear and dark red colour, poorly-, moderate- and richly marbled, fibery, moist, smooth and a homogeneous colour. All these 23 attributes mentioned above that were perceived of over 50 percent of the respondents in at least one of the four meat samples are generating the terminology for beef and answering the aim of the study.

One interesting observation that has been seen during this study is the fact that the meat appearance that the consumer sees as most attractive does not correspond to the meat they prefer regarding taste and texture. As seen in the results from the "willing to buy" CATA question, consumers prefer meat with not that much marbling, a clear red colour and a moist appearance (meat sample nr. 1). When the same consumers are tasting the meat, it appears that the sample with the highest amount of marbling and the darkest red colour (meat sample nr. 2 and 3) is the one that scores highest in palatability. In Smith and Johnsons article it has been proven

that meat with a higher marbling grade, and therefore also higher amounts of oleic acid and other monounsaturated fatty acids, have been improving the overall palatability of beef (Smith and Johnson, 2016). As mentioned above, palatability and marbling grade has a positive correlation in this thesis as well. Meat nr. 2 and 3 with the highest marbling grade also have the highest values for four of the top five ideal attributes in both flavour and texture. This can be seen in figure 8 and 10. Therefore, it can be concluded that consumers need to change their mindset when shopping beef and start looking after darker meat with more marbling to get the quality they seem to prefer. As mentioned in the introduction, studies have shown that consumers are willing to pay more for meat that is meeting their quality expectations (Nguyen and Gizaw, 2014). This knowledge may be useful in future marketing to increase the value of beef, and in that way also increase the profits for farmers and slaughter companies.

Another interesting observation that has been seen in this thesis is the correlation between grade of tenderness and juiciness. In previous studies it has been proven that the top three palatability characteristics are texture, juiciness and flavour/odour with texture as the most important for consumers (Corbin et al., 2015). Meat sample 2, the 28 months old cow with the highest marbling grade had 97% of the respondents rated as juicy and 90% as tender. Meat sample 3, the 45 months old cow with the second highest marbling grade of our four samples had 90% of the respondents rated as juicy and 67% as tender. Meat nr. 1 and 4 had the lowest juiciness and tenderness rate despite that they came from cattle slaughtered at a lower age than meat nr. 3. This corresponds to the studies described by P.D. Warriss that shows that meat with a higher grade of juiciness interrelates to a higher grade of tenderness (Warriss, 2000). Therefore, it can be concluded that the tenderness and juiciness is mainly correlated to the grade of marbling rather than the age of the cattle. This could also be an important thing for slaughter companies to highlight in future promotion of meat products to increase the sales.

The only beef sample in this study that came from grass-fed cattle was sample nr. 1. According to the non-profit association “Grass-fed meat in Sweden” this type of meat is not only better for the animal welfare and climate, it also gives the meat a tasteful, tender and extra juicy flavour and texture (Naturbeteskött Sverige, 2019). Regarding the palatability, this was not the case according to the results from the CATA analysis in this study. Meat sample nr. 1 did not score the highest in neither flavour nor texture compared to the ideal and the other three samples. One of the reasons why consumers rate this type meat higher in palatability according to the

non-profit association “Grass-fed meat in Sweden” could be the fact that they have a better experience of a grass and forage based production systems compared to conventional systems. Knowing that the meat you are eating have a greater impact on the climate and animal welfare can affect the whole perception of the eating experience. It is important to highlight the fact that conventional cattle’s in Sweden also, by law, have to be outdoor grassing for at least 60 days per year, which is a significant factor for a positive animal welfare (Jordbruksverket, 2019b). This is in one way equal to the grass based production system. However, the difference between these systems is that conventional cattle is not obligated to graze semi natural pastures half of the outdoor grassing period (Naturbeteskött Sverige, 2019). As mentioned earlier, one thought is that many consumers might have a negative association to the word “conventional” even though the Swedish way of conventional rearing is among the most prominent in the world in terms of animal welfare. One way to improve the consumers eating experience and, in that way, also increase the consumption of Swedish beef might be to inform consumers about factors that creates added values to the meat, such as the origin of the meat, rearing system used and how these factors correlates to different meat characteristics in the end. Hopefully, the terminology developed in this thesis makes it easier to describe meat in a more attractive way, which in turn might bring an added value to the product, improve the eating experience and increase the consumption of Swedish beef.

5.3 Future research

There are many ways to perform a sensory investigation for texture, flavour and appearance for beef. This study needs further investigation to be able to call it a general terminology for beef. 30 respondents in the CATA method cannot stand for all consumers opinions regarding sensory properties of beef. Although this study provided 23 sensory attributes for the terminology, a larger amount of people in the study and more cuts from different parts of the animal would have made it more credible. A higher number of animals, greater spread in slaughter age and several different breeds would also have affected the result in a positive direction. Except for the animal factors, a trained panel calibrated to beef in the open discussion generating the attributes to the CATA method would have provided a larger amount of describing words and a more credible final result. This was unfortunately not achievable in this study due to limitations in time and costs.

6 Conclusion

This thesis resulted in a terminology for beef that can be found in the discussion part in this report. All attributes were found in at least one of the four meat samples for over 50 percent of the respondents. Hopefully, the generated attributes from this study can be used for further research to obtain a broader and more general terminology, but also as sensory marketing words for beef and Strip Loin.

Based on the “willing to buy” and “acceptability” results in this thesis it has been concluded that consumers of Strip Loin from beef do not choose cuts in the store that visually corresponds to their ideal palatability. It is a future challenge for slaughter companies and food retail stores to enlighten the consumers about the connection between appearance and flavour in an educative way.

The technological outcome from this study indicates that the generated attributes for the terminology and the results from the pH- and the colour measurements do not correlate in any way.

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9 Appendix

9.1 Popular scientific summary

The question regarding meat eating today is highly debated. In Sweden, the intake of meat per capita is decreasing while the intake of Swedish meat is increasing. One of Sweden's largest slaughter companies, HKScan's biggest goal is to keep this trend and to make the consumers realize that Swedish meat is one of the best in the world when talking about animal welfare and climate. One solution to keep this trend is to make Swedish meat, and especially beef, something valuable and luxurious. To make the consumers realize that they are not just eating a piece of food and instead think of the beef like an eating experience, just like most people do with wine. The biggest problem is to describe beef in an attractive way. The wine industry has basically an infinite vocabulary to describe the aromas while the meat industry is talking about beef in the terms of "good" or "bad". To change this, a terminology for beef needs to be invented. Both consumers, slaughter- and meat companies need words to use when describing the eating experience from a piece of beef.

It has been shown that consumers are willing to pay more for food products that has a describing name. To put something in a context makes it easier for consumers to picture the beef on the plate with flavour, texture and an appearance that matches with the rest of the food in the meal. A piece of tender Strip Loin with flavours of caramelized nuts and a meaty mature tone is easier to imagine together with your mellow red wine sauce, crispy haricots verts and buttery baked potato instead of just a Strip Loin. To make this desire come true, we believed that a terminology for beef products had to be invented and that was the aim with this study.

Three pieces of Strip Loin from beef with different marbling grades and one piece of Strip Loin from a grass-fed animal were chosen to the study to generate the describing words. To generate these words, two sensory methods were used, one qualitative open discussion and one quantitative CATA (Check-all-that-apply). In addition to this, two technological analyses were done. pH- and colour measurement to see if there were any significant differences between the samples and if there were any correlations between pH- and colour values and the generated terminology.

The result from the pH measurement showed no overall significant differences between the samples. The colour measurement did show an overall significant difference between the samples. No correlations between pH, colour and the generated terminology could be found. The result from the sensory analysis showed that over 50 percent of the respondents in the CATA method could detect a taste of umami, mineral, moderate meaty, nutty, buttery, mellow and mature in at least one of the four meat samples. The texture words that over 50 percent of the respondents could detect were juicy, tough, tender, firm, soft, dense fibre structure and porous fibre structure and the appearance words were clear and dark red, homogeneous colour, poorly-, moderate- and richly marbled, fibery, moist and smooth. All these words were generated to describe beef in a more attractive way. Using these words in sensory marketing could be one option for HKScan to make beef more attractive for the consumers and in that way also maintain, or even increase, the demand of Swedish meat on the market.

9.2 Attributes to CATA questions

Table 12 Flavour attributes to CATA method, strikethrough words were provided from the open discussion but not used in the CATA questions.

SE Smak	EN Flavour
Intensiv köttsmak	Intense meaty
Måttlig köttsmak	Moderate meaty
Mild köttsmak	Bland meaty
Besk	Bitter
Söt	Sweet
Salt	Salty
Syrlig	Sour
Umami	Umami
Blod	Blood
Metall	Metal
Järn	Iron
Mineral	Mineral
Kritig (kalk)	Chalky
Jordig	Earthy
Vilt	Gamey
Svamp	Mushroom
Skog	Forest
Trä	Wood
Tall	Pine wood
Barr	Fir needle
Granskott	Fir shoots
Kåda	Resin
Mossa	Moss
Gräs	Grass
Ensilage	Silage
Hö	Hay
Örter	Herbs
Mjölk	Milk

Kortlagrad ost	Short-aged cheese
Långlagrad ost	Long-aged cheese
Opastöriserad ost	Unpasteurized cheese
Jäst	Yeast
Nötig	Nutty
Smörig	Buttery
Oljig	Oily/Fatty
Blommig	Floral
Fruktig	Fruity
Bärig	Berry
Citrus	Citrus
Pepprig	Peppery
Karamelliserad	Caramelized
Svavel	Sulfur
Härsken	Rancid
Oxiderad	Oxidized
Från	Acrid
Skarp	Pungent
Lagrad	Aged
Mogen	Mature
Mustig	Rich
Fyllig	Mellow
Köttig	Meaty
Rökig	Smoky

Table 13 Appearance attributes to CATA method, strikethrough words were provided from the open discussion but not used in the CATA questions.

SE Utseende	EN Appearance
Blöt	Wet
Fuktig	Moist
Torr	Dry
Ljusröd	Light red

Klarröd	Clear red
Mörkröd	Dark red
Lilaröd	Purpleish-red
Brunröd	Brownish-red
Gråröd	Grayish-red
Svagt marmorerad	Poorly marbled
Måttligt marmorerad	Moderate marbled
Rikligt marmorerad	Richly marbled
Fibrig	Fibery
Fast	Firm
Måttligt fast	Semi-firm
Måttligt mjuk	Semi-soft
Mjuk	Soft
Slät	Smooth
Sträv	Coarse

.

Table 14 Texture attributes to CATA method, strikethrough words were provided from the open discussion but not used in the CATA questions

SE Textur	EN Texture
Torr	Dry
Saftig	Juicy
Seg	Tough
Mör	Tender
Sträv	Coars
Grov	Rough
Fibrig	Fibery
Tät fiberstruktur	Dense fiber structure
Gles/porös fiberstruktur	Porous fiber structure
Fast	Firm
Mjuk	Soft
Grynig	Grainy
Homogen	Homogeneous

Slät	Smooth
Flagig	Flaky
Sladdrig	Flabby
Klibbig	Sticky
Silkig	Silky

9.3 CATA questions

Utseende

Fyll i ”Ja” för alla de ord och fraser som du **tycker** överensstämmer med din idealiska bild av en bit biff från nöt. Fyll i ”Nej” för alla de ord och fraser du **inte tycker** överensstämmer med din idealiska bild av en bit biff från nöt.

Utseende

- Fuktig
- Torr
- Ljusröd
- Klarröd
- Mörkröd
- Lilaröd
- Brunröd
- Gråröd
- Homogen färg
- Svagt marmorerad
- Måttligt marmorerad
- Rikligt marmorerad
- Fibrig
- Slät

Titta på prov nummer X och fyll sedan i ”Ja” om du **tycker** ordet eller frasen stämmer överens med provet och ”Nej” om du **inte tycker** ordet eller frasen stämmer överens med provet.

Utseende

- Fuktig
- Torr
- Ljusröd
- Klarröd
- Mörkröd

- Lilaröd
- Brunröd
- Gråröd
- Homogen färg
- Svagt marmorerad
- Måttligt marmorerad
- Rikligt marmorerad
- Fibrig
- Slät

För alla prover efter den visuella bedömningen (innan provsmakningen):
Är detta en köttbit du hade kunnat tänka dig att köpa i butik? Ja=1 Nej=2

Smak och textur

Fyll i ”Ja” för alla de ord och fraser som du **tycker** överensstämmer med din idealiska bild av en bit biff från nöt. Fyll i ”Nej” för alla de ord och fraser du **inte tycker** överensstämmer med din idealiska bild av en bit biff från nöt.

Smak
- Intensiv köttsmak
- Måttlig köttsmak
- Mild köttsmak
- Besk
- Syrlig
- Umami
- Mineral
- Vilt
- Skog
- Trä
- Opastöriserad mejeriprodukt
- Gräsig
- Örtig
- Blommig
- Nötig
- Smörig
- Oljig
- Mjölkig
- Pepprig
- Karamelliserad
- Oxiderad
- Bismak
- Fyllig
- Mogen

Textur

- Torr
- Saftig
- Seg
- Mör
- Sträv
- Fast
- Mjuk
- Tät fiberstruktur
- Gles/porös fiberstruktur

Smaka på prov nummer X och fyll sedan i ”Ja” om du **tycker** ordet eller frasen stämmer överens med provet och ”Nej” om du **inte tycker** ordet eller frasen stämmer överens med provet.

Smak

- Intensiv köttsmak
- Måttlig köttsmak
- Mild köttsmak
- Besk
- Syrlig
- Umami
- Mineral
- Vilt
- Skog
- Trä
- Opastöriserad mejeriprodukt
- Gräsig
- Örtig
- Blommig
- Nötig
- Smörig
- Oljig
- Mjölkig
- Pepprig
- Karamelliserad
- Oxiderad
- Bismak
- Fyllig
- Mogen

Textur

- Torr

- Saftig
- Seg
- Mör
- Sträv
- Fast
- Mjuk
- Tät fiberstruktur
- Gles/porös fiberstruktur

För alla provbitar:
Hur mycket ogillar/gillar du denna köttbit?
Ogillar=1,2,3,4,5,6,7,8, Gillar=9
Ogillar ---------- Gillar

Övriga frågor

Fråga 1. Hur många gånger i månaden konsumerar du bitar av styckdetaljer så som entrecote, biff, filé eller liknande?

Varje dag (1)
3–5 gånger i veckan (2)
1–2 gånger i veckan (3)
2–3 gånger i månaden (4)

Fråga 2. Hur många gånger i månaden köper du hem bitar av styckdetaljer så som entrecote, biff, filé eller liknande?

Varje dag (1)
3–5 gånger i veckan (2)
1–2 gånger i veckan (3)
2–3 gånger i månaden (4)

Fråga 3. Är det du som tillagar styckdetaljerna hemma efter inköp?

Ja=1
Nej=2

Fråga 4. Hur många gånger i veckan äter du kött? Inräknat pålägg och charkuteriprodukter, sammansatt produkt tillexempel ost- och skinkpaj, malet kött i form av färs m.m.

Varje dag (1)
3–5 gånger i veckan (2)
1–2 gånger i veckan (3)
2–3 gånger i månaden (4)

Frågor från screener / urval av konsumenter till undersökningen

Q1.Age	Hur gammal är Du? 1. Yngre än 20 år 2. 20-29 år 3. 30-39 år 4. 40-49 år 5. 50-59 år 6. 60-65 år 7. Äldre än 65 år	Jämn fördelning 20-65 år
Q2.Gender	Vilket kön har du? Med kön menar vi könsidentitet, alltså det kön du själv känner dig som. 1. Kvinna 2. Man 3. Annat alternativ 4. Osäker 5. Vill ej svara	Kön: 50% män
Q4c.Ansvar_inköp	Hur stor del av hushållets inköp av mat- och hushållsvaror är du ansvarig för? 1. All 2. Mer än hälften 3. Ungefär hälften 4. Mindre än hälften 5. Inget	Ansvarig för hushållets inköp av mat 1-2-3

Q8.	Du har svarat att du ibland äter nötkött. När det gäller tillagning, hur tycker du om att äta nötkött såsom biff? Vilken tillagning/vilka tillagningar tycker du om? Flera svar är möjliga. Vilken tillagning tycker du bäst om? Vilken tillagning/vilka tillagningar accepterar du att äta även om det inte är ditt förstahandsval? Flera svar är möjliga. Rare (1) Medium (2) Well done (3)	Ska äta Medium (2) Och rare (1)