Somatic cell count and bacteria count in Norwegian goat milk

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Factors of variation and influence

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Preface

To finish my EED Livestock Production program, I had to make a company placement to solidify my academic knowledge but also and especially to apply it within a company. I then had the opportunity to join the department of Research and Development in Dairy Production at TINE SA, the largest Norwegian dairy cooperative. They included me in the GoatMilkSCC project in partnership with the Norwegian University of Life Science. This project started in 2020 and will finish in 2024. In the end, the goal is to know why the somatic cell count is that volatile around the year and why it increases a lot, especially during summer.

I really would like to say thank you to all my colleagues from the R&D department for welcoming me from the first day I arrived. Particularly to Eirik Selmer-Olsen who welcomed me on the first day and was present throughout my internship at my side.

I would also like to thank Marit Smistad who took the time to accompany me during this internship and who taught me a lot.

Finally, I would like to thank Ragnhild Aabøe Inglingstad who supervised my entire internship. She allowed me to participate in interesting missions and visits to beautiful farms. I also thank her for giving me the means to write this thesis, and for helping me to complete it.

I also address thoughts to the Norwegian farmers whose farms I visited because it was each time a new experience where I learned a little more, and to all the other people that I met during this internship.

Passionate about goats, this placement was for me the best opportunity to explore new aspects of this production while discovering the wonderful country of Norway. The subject of this thesis was for me very interesting because it joined the subject of my work placement and my high interest in goat milk production.

Thanks to this thesis I learned a lot about goat milk quality and especially about the somatic cell count and the bacteria count. I will use this new knowledge in my future job for sure.

This placement was an incredible experience for me, both professionally and personally, and I am very grateful to have had this opportunity.

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Glossary

ANOVA: statistical test to compare qualitative and quantitative variables, include linear regression

DNA: deoxyribonucleic acid, carrier of genetic information

Kg: kilogram

mL: milliliter

Pearson test: statistical correlation test for quantitative variable

P-Value: value that defines the significance level of a result, it must be less than 0.05 for the result to be significant

R^2: coefficient which shows the part of the quantitative variable explained by the qualitative variable. Given thanks to the linear regression of two variables in the ANOVA test.

SCC: Somatic cell count

Summary

The dairy goat sector in Norway is confronted to a certain problem since many years, the increase of the cells in goat milk. This cell issue seem to become a big problem for the goat farmers because the somatic cell count and the bacteria count are the base of the payment grid. Other studies in the world found the same results as in Norway, and searched some explanation for this increase during summer, but Norway don't know if these results can be applicable to their herds. Due to a very high cell count or bacteria count, farmers are less paid and it can decrease the quality of the dairy products. It is therefore important for all the actors in the Norwegian dairy goat sector to know the causes and how to manage them in order to improve this component in goat milk. For that, the company TINE, associated with the Norwegian University of Life Science started a 4-years project about the somatic cell count in goat milk. This year nine goat farms, located in different areas in Norway were analyzed. Milk and teat samples from each goat were taken in 3 periods: during spring, when goats are still in the barn, during summer when goats are grazing in the pasture, and finally during autumn, when goats are back in the barn, it is also the heat and mating season. The parity of each goat has been collected as well. With these data, the following question emerged :

What is the impact of the seasons and the parity on the somatic cell count and bacteria count in Norwegian goat milk?

To answer this question, milk analysis from laboratories was received and used to make statistical Pearson correlation tests and ANOVA tests, including linear regressions. The seasons seem to explain 30% of the variability of the somatic cell count and summer makes it double or even triple. For the bacteria count, seasons seem to explain 23% of its variability, but this result is not statistically significant. In a general way, yes seasons have an impact and especially summer which makes it increase a lot. About the parity, it seems to explain 18% of the somatic cell count variability, but there is no correlation with the bacteria count. The somatic cell count increase with the number of parity until the 4^{th}, and becomes stable while remaining high after the 4^{th} one. The type of bacteria strains is not influenced by the seasons and the parity according to the statistical analysis.

In a general way, somatic cell count is particularly influenced by seasons and parity, with a total of almost 50% of its variability explained by these two factors. However it is not the case for the bacteria count, but researchers have doubts about the techniques used in laboratories and their accuracy.

Farmers should cull their goats earlier, at 4 or 5 parities to decrease their herd means of SCC. They also should try to decrease as much as possible all the stress factors for the goats, especially during summer, and stop mixing herds in mountain pastures. Finally, further scientific studies could clarify the found results and give more details thanks to other goat farms.

1. Chapter 1: Introduction

1.1. Norway, an agricultural area

The Norwegian agricultural sector is predominantly based on livestock production, with 35% of the total agricultural product coming from dairy products, and 30% from meat production (Europa-planet, n.d.). Indeed, the climate and the relief make Norway a difficult territory to cultivate, which does not allow them to produce many cereals. With 213,200 dairy cows and 36,000 dairy goats, Norway has a fairly large milk production for internal consumption but also for export, especially to European countries. In Norway, cow's milk is mostly consumed raw, but cheese production is also important. While goat's milk is almost exclusively used for the production of "Brunost", a brown cheese made by caramelizing lactose.

1.2. The Norwegian goat milk production and its actors

As said before, Norway's climate and terrain make land use difficult. Only 3% of the country is agricultural land, the rest is 37% forest and finally mountains (Ådnøy, 2014). This geography is difficult for crops and cattle breeding, but it is rather favorable for goat farming. Norwegian goats are hardy and have a character and physique that allows them to enjoy living in the mountains. This allows farmers to use these lands that only goats can access, even if it is only 3 or 4 months a year during the summer. Even though goats enjoy the mountains, farmers need to produce milk in good quantity to have a good income, and for that, they need to eat more than what they can find only in the mountains (Ådnøy, 2014). That's why the goats receive good quality concentrates and supplementary roughage all year round, both during the barn period and during the grazing period. This allows Norwegian goats to produce on average of 716 kg of milk per year with 4% fat and 3% protein according to the TINE Dairy Goat Control (Ådnøy, 2014). Indeed, TINE is the only Norwegian dairy cooperative that collects goat milk from farms. It is also in charge of advising the farmers on their farms. Goat advisors address all aspects of the farm and help farmers improve certain things based on their results and goals. This can be about genetics, feeding, milk quality, or the economics and management of their farm for example. TINE asks for the Dairy Goat Control to do at least 5 controls per year on the farms. These controls are milk samples from the tank but also from each goat, and the amount of milk is weighed. Thanks to these controls and results, TINE collects a lot of data that allows it to research to improve the quality of milk.

1.3. Current issues of this sector

It is estimated that a goat should have less than 750,000 cells, beyond this number it is characterized as an infection, whether it is light or more important, up to mastitis (Drutel & Chavanat, s.d.). The dairy company TINE has detected for several years that the somatic cell count was constantly increasing, especially at certain periods of the year, for example, it is not unusual to have goats with about 2 million cells. But also that the bacteria count in the udders was sometimes very high depending on the animals. Indeed it was observed that the SCC increased enormously during the grazing period, but they also wondered what other factors impacted SCC outside of this period. Following these observations, TINE's advisors and researchers then looked into this subject to try to determine what the causes and consequences of these factors were. Since 2020, the GoatMilkSCC project has started and is working on this topic (Inglingstad, 2021). In 2021, research has started to find out if the somatic cell count affects the quality of cheese (Smistad et al, 2022).

Beyond the repercussion on the quality of the cheese, the SCC is a determining factor of the quality of the milk and thus of its price because SCC is one of the payment base criteria. It is also an indicator of the udder health and therefore of the goat. This problem of SCC and bacteria increase concerns for both farmers, and advisors but also milk collectors like TINE. All these people are concerned and are looking for explanations for this phenomenon to manage it better. This study and this project are important because it seems necessary to find out where this contamination comes from to improve the farmers' wages, and the health of the goats' udders but also to ensure the quality of the processed product afterward.

1.4. The somatic cell count: an important indicator

The Somatic Cell Count (SCC) is an indicator that determines the number of somatic cells in the milk. In this count, two types of cells can be distinguished. Most of the cells in the udder are leukocytes (or white blood cells) which are the main protection against pathogens. Leukocytes consume these pathogens to avoid an infection of the udder, otherwise called mastitis. These white blood cells increase in quantity when there is a lot of bacteria in the udder, and therefore an infection (Ontario Ministère de l'agriculture, de l'alimentation et des affaires rurales, 2021). The second type is the epithelial cells, which are the residual cells that result from the cellular renewal of the internal mucosa of the mammary gland. These cells are "normal" and do not mean abnormalities even if they are in large numbers, especially in the goat. Goats do not produce milk in the same way as cows, and the synthesis of goat's milk involves a higher content of skin cells and cell fragments containing DNA (Hoste et al., 2012). A normal SCC is about 750 000 cells, lower than this number, goats are considered healthy, over this number, goats are considered not healthy and infected, but when goats are above 1,5 million it is very high and generally means that there is an infection. In general, a very high SCC indicates the presence of an infection. However, since goats have a large number of epithelial cells included in the SCC, this indicator is not so representative of the presence of a mammary infection in the goat udder (AHDB, n.d.).

1.5. The bacteria count to learn more about the udder health

The bacteria count corresponds to the number of detected bacteria in the taken milk samples. Thanks to microbiological tests in the laboratory it is now known how many bacteria cells there are in the udder, and which strain is it (Park & Humphrey,1986). Bacteria count permits to have a good overview of the contamination in one flock, and if one bacteria is overbalanced, it is also easier to treat it and manage to reduce its presence.

Both somatic cell count and bacteria count are good indicators of milk quality but also of farm management. Explanations on the quality of the milk that the farmers deliver can be given thanks to these indicators. It also permits farmers to know if there is bacterial contamination in their farms and if so, to seek to eliminate them or at least reduce them.

1.6. SCC: an indicator with several influence factors

For the last few decades, research has been carried out to find out the factors influencing SCC. These influencing factors are numerous and diverse, which makes it difficult for farmers to identify them. As explained earlier, in SCC, white blood cells and epithelial cells are counted. This composition allows for distinguishing several influencing factors: those that will increase the number of white blood cells, and those that will increase the number of epithelial cells. In all cases, the factors are numerous but have been globally distinguished thanks to numerous scientific types of research.

First, there are infectious factors, which indicate the presence of one or more bacteria in the udder. This infection will lead to an increase in immune defenses and therefore white blood cells. Intra-mammary infection is the first cause of an SCC increase because it can make the cell count rise very quickly. If not treated in time this infection can lead to mastitis. In most cases, these infections are caused by contagious bacteria such as Staphylococcus aureus, Staphylococci, Streptococci agalactiae, Streptococci Group C, and Mycoplasma (Granado et al., 2014).

After the infectious factors, there are the non-infectious factors, which are therefore dependent on each animal itself. These factors can be intrinsic, means that they come from the animal itself and which are non-modifiable characteristics, or they can be extrinsic factors, means that they depend on the animal but especially on the breeding practices that are allocated to it. These non-infectious factors are numerous, but the most common are the following ones.

For intrinsic factors, it is about parity, number of lactations, breed, and hormonal cycle. The breed of goat seems to have an impact. Indeed, some breeds show to be more resistant to bacteria, and others are more fragile. Genetics is a determining factor that could be used to select in each breed the most resistant individuals to transmit this resistance.

Finally, the heat period very commonly shows an increased SCC. In a seasonal production like goats, the heat period happens in the autumn, and some studies show an increase of SCC in the autumn, which can be related to the heating season but also the late stage of lactation (Wilson, 1994). According to different studies, this could be explained by the decrease in milk production at this period and therefore a higher cell concentration. One study may explain this phenomenon by the effect of hormones such as steroids or proteins that may affect CSC (McDougall & Voermans, 2002).

The number of lactations and parity seems to be influencing factors and this could be explained by the fact that the older the goats are, the more they are exposed to bacteria and therefore they potentially have a reservoir of bacteria that is not sufficiently sanitized during the dry period. One thing that all studies agree on is that parity is a key determinant of CSC. The University of Ilorin study shows, for example, that in a sample of 48 goats, in the first year they have an average of 1.89 *105 cells/mL, and in the third year an average of 2.16 *105 cells/mL. This shows that primiparous goats have a higher immunity in their udder than goats of third parity or higher. This may be explained by exposure to milking which damages the mammary gland and thus leads to lower immunity (Yusuff et al., 2021). The results are quite the same in Turkey where primiparous and multiparous Turkish goats were compared, the first ones were on average at 686 $*10^3$ and the second ones at 905 $*10^3$, the conclusion is the same (Orman et al., 2010).

Extrinsic factors are generally the type of milking, feeding, stress, and finally the farming system and seasons (Granado et al., 2014). For the milking type, it depends on if it is made by hand or thanks to a machine. The most relevant criteria seem to be the setting of the milking machine (duration and number of pulses) which could affect the quality of the udder and deteriorate the internal cells because of a bad setting in the long term, even if different studies do not agree on the relevance of this criteria.

Secondly, inadequate feed for the animal, which could cause metabolic diseases such as acidosis, could lead to an increase in SCC. This would be due both to the stress created by the disease and the pain, but also by a lower quantity of milk produced and therefore a higher cell concentration. An adapted daily intake would therefore lead to a lower SCC. Another factor in the increase of SCC seems to be the seasons and the farming conditions.

The seasons, related to the housing conditions, seem to be influential criteria, especially because of the humidity, the luminosity, and the general living conditions. Depending on them, the hygiene can be different and makes appear bacterial infection for example, but a lot of criteria can be included in this seasonal risk factor. A study shows that daytime grazing induces an increase in SCC during the summer period, mainly explained by heat stress due to sun exposure. This study also explains that grazing during the night allows for keeping the advantages of grazing (quality and quantity of milk), without increasing the SCC (Di Grigoli et al., 2016). Another study shows that there is indeed an increase in SCC during the summer period on pasture, but this can be explained by the fact that it is the end of lactation and therefore the cell concentration (counted in cells/mL) is necessarily higher as the goat produces less milk. With seasonal production and farrowing, an increase in SCC would be noted in late summer and autumn during the first days of estrus (Margatho et al., 2018), with the decrease in milk quantity and the stress of the presence of males (Granado et al., 2014). Finally, the increase in SCC during the grazing period seems to be due to the feeding stress of having a lot of food available, but it can also be related to the weather and the type of grazing: grasslands or mountains (Kvamsås, 2018).

1.7. Bacteria count, another indicator of the udder and goat health

Less research has been done on the bacterial count in goat farming, although it is a valuable indicator that can help a great deal in understanding farm performance. Indeed as seen previously that part of the cells counted in the SCC were white blood cells. And these white blood cells grow in large numbers when there are one or more bacteria that enter the mammary gland. As the white blood cells are the only defense that the mammary gland has, their number can increase enormously and very quickly.

As seen before the SCC tended to increase with the age of the goats and their parity, however, for the bacterial count, the result is not the same. For example, over 10 years of milk samples analyzed in the study of TINE SA it emerged that he number of bacterial infections was found to decrease with parity (Smistad et al., 2021). The most common strains are mostly Staphylococcus aureus, but others are *Staphylococcus warneri*, *Staphylococcus epidermidis*, *Staphylococcus caprae*, and *Streptococci*. The risk factors for bacterial contamination in the udders of goats are multiple and quite the same as for SCC. There are for example the breed, the age of the goat, its parity, but also the conditions of the udder, its condition, and its hygiene. As *Staphylococcus* is predominant in analyses, current research has been based solely on this strain of bacteria.

Thus it seems that the breed is an important factor of influence, indeed the Saanen goat seems to be less disposed to have been infected by *Staphylococcus* than an Ettawa goat (Taufik et al., 2008). Parity and stage of lactation were also recognized as influencing factors thanks to significantly correlated results. Finally, in addition to these criteria, the condition of the teat end also seems to be an important factor.

(Taufik et al., 2008). In the end, thanks to more advanced statistical analyses, it is the "Lactation stage" and “udder inflammation” factors that remain the most significant in this study (Taufik et al., 2008).

For the type of bacteria, some strains are mainly present in the udders of goats, for example: *S.aureus*, *S.caprae* and *S.warneri*. These strains are almost always accompanied by a high number of cells and bacteria. Their presence means something and for that, it is important to know in which situation they are developing. The S. Aureus is a coagulase-positive bacterium that can be found in the environment of goats, for example during milking. The same goes for *S.caprae* which can also be found in the environment. *S.warneri* is a little different because it is a normal host present on the skin and mucous membranes of animals, so it is important to make sure that its presence does not multiply, but without eradicating it (Bernier-Gosselin, et al., 2021).

1.8. The issue persists and questions are still here

All these studies permit to have a good overview of the sanitary situation of goat’s udders in the world. In Norway, the dairy company TINE SA see the problem of a high cell count and bacteria count for many years but still doesn’t have found the real causes and consequences of this. So far the GoatMilkSCC project has leaned more towards the side of consequences by looking at whether this had an impact on the quality of the cheese. However, the problem persists and it is now important to deal with the problem at its source.

It therefore know, thanks to all these studies, the different risk factors that can impact the quality of milk in terms of SCC and bacteria, but it is not known which ones apply to Norwegian goat herds, and how farmers can manage them to improve their SCC and bacteria count.

1.9. A current issue that needs research

It is known that it is difficult for farmers to change their practices, which is why companies need to offer them simple adjustments such as better management of pasture and buildings or culling the right goats at the right time. Previously, it was shown that the most dominant factors of influence are the parity of the goats, as well as the season of the year. Norway is keen to maintain a clean image and animal welfare, which is why these criteria based on the grazing seasons as well as on the selection of animals seem appropriate.

Finally, companies and farmers want to know if parity has an impact on the SCC and the bacteria count of Norwegian goats, but also if the season (grazing or breeding seasons) also influences these criteria.

1.10. SCC and bacteria count in Norwegian goat milk: the main interrogation

Thanks to the literature on the theoretical framework and the knowledge gap of this subject, one question seems to stand out:

What are the influence of the season and the parity on the SCC and bacteria count in Norwegian goat's milk?

To answer this question, some intermediate questions will lead to the main question's answer:

- What is the impact of the seasons on the Norwegian goats' SCC and bacteria count?
- What impact does parity have on SCC and bacterial counts in Norwegian goat's milk?
- Are some strains of bacteria more present than others depending on the season and the parity of the goats, and what is their impact?

1.11. An important research for all the goat milk sector's actors

This research is done to complete the GoatMilkSCC project of TINE SA, which is a project over the years for Norwegian goat farming improvement in Norway. Thanks to this research it will be known if there is a correlation between the SCC and bacteria count, the season, and the parity in Norwegian goat milk.

The SCC issue is there for many years and it is time to find solutions for the farmers. With the results, Norwegian goat farmers, goat advisors, and goat milk collectors will have insight into this issue. It will permit to know how to manage the culled goats at a good age depending on their SCC and bacteria count, and also how to manage the grazing and mating period in Norwegian goat farms.

The objective of this thesis is to know if the found literature about the risk factors of SCC and bacteria in goat milk is applicable to Norwegian goats. This will permit farmers to improve their milk quality and thus their income as the SCC is a criteria payment.

This thesis will be sent to the Department of Research and Development in Dairy Production of TINE SA at As (Norway). After that, technicians and advisors of TINE will use these results to manage the goat farm's results in Norway. It will permit them to make choices and maybe change some practices.

If results show that the grazing seasons impact SCC and bacteria count, thanks to the literature advisors could propose farmers to make grazing their goats during the night for example. If the results show that there is more bacteria contamination at home grazing or at stol, farmers could change it. If results show that the parity is high, more SCC is high, farmers must cull their goats earlier in age, or cull them at least when the SCC is more than the recommended amount.

2. Chapter 2: Material and method

The study was mainly quantitative with milk quality data collected from 9 goat farms in Norway during 3 key periods of the year: spring, summer, and autumn. The data from these farms were analyzed using statistical correlation tests to answer the study questions.

2.1. Material

The study took place during the autumn and beginning of winter 2022 at the TINE Department of Research and Development located at As, in the South-east of Norway.

Data used from the farms will be from the current year 2022. Data came from nine goat farms in Norway that took milk samples of each of their goats at three different periods of the year. The nine farms have different sizes as it is described below in table 1.

Table 1: Size of the nine goat farms of the study

Farm	n (goats)
OST 1	98
OST 2	109
OST 3	112
OST 4	67
VEST 1	90
VEST 2	134
NORD 1	190
NORD 2	76
SHF	81

The first studied period is during spring (May or June) when goats were still inside the barn, 3 weeks before the let-out in pasture. The second period was during summer (July) when goats were outside, this period was the grazing period in pasture, usually in the mountains. Samples were taken about two weeks after the beginning of the grazing period for each farm. The last period was when goats are back in the barn in late September, or October depending on the farm, this period corresponded to the heat and mating period. Samples were taken 3 weeks after they came back in the "winter farm".

For all the goats of each farm, two types of samples were taken. The first one was a milk sample, to have the milk contents like quantity, fat, protein, SCC, and total bacteria count. The second one was a teats sample to know if there was a presence of bacteria on each side of the udder, one sample is taken for the right mammary gland, and another one is taken for the left mammary gland.

Thanks to these samples, a dataset was created for each of the nine farms.

In total, milk samples gave a lot of information about milk quality, but the study focalized only on the SCC and bacteria count. The SCC variable in each farm was composed of the result of each goat, it was written in $*10^{-3}$ cells/mL of milk. The bacteria count variable was composed of the raw result of each goat at each period, it was written as the number of bacteria cells per mL of milk.

The teat samples gave the result of which bacteria were present in the udder. The variable was composed of the result of each goat for both sides of the udder. After that, a code number was attributed to each combination of bacteria (see Appendix 1).

To know if parity has an impact on the SCC and bacteria count, the parity of each goat of the nine farms was collected from the Norwegian goat recording system where all the data from the Norwegian herds are stocked.

Finally, a summary table of the data collected for this research is in Appendix 2.

In addition to these quantitative data, farmers answered a qualitative survey already prepared by TINE in 2021, which gave more information about technics and practices used on these farms to complete the study and the interpretation of the results. Questions were about :

- The transport from the farm to the pasture (stress factor)
- The type of pasture: mountain, pasture at the farm, mixed with other herds, altitude
- The indoor/outdoor access during the grazing period: do goats have the choice or not?
- The barn condition during the indoor period (spring/autumn): number of m^2 per goat
- Observations of the farmer: if they see more aggressive behavior during a certain period, if they see more stressful behavior in a certain period
- How farmers think about SCC reduction and what their strategy would be

2.2. Method

To make this study, nine chosen farms were analyzed, those which were partners of the TINE GoatMilkSCC project in 2022. Each year about 10 goat farms are used for the project, they are from different areas in Norway to have a good overview of the results. These farms were partners in the project because they wanted to improve their milk results and participated in the evolution of the dairy company TINE. These farms were analyzed thanks to statistical tests and answers from the survey were also collected.

Qualitative data from the survey:

The survey was sent in 2021 and TINE SA received about 100 answers from goat farmers. In total, 15 questions from the survey were selected (see Appendix 3). As described before, these questions were about: the grazing period and its management but also about the spring and mating season (indoor period). So the questionnaire was mainly used to explain the season's correlation with the somatic cell count and bacteria count (season's sub-question). Given answers to these questions by the nine farmers of the study were extracted from the database and included in a new Excel dataset, especially for the research.

The questions for each period permitted to have a better interpretation of the result. For example, a high cell count during the indoor period can be caused by a barn that is too small for the number of goats and created a stressful situation, and do, increasing the SCC. Or if two or three herds are mixed during the grazing period, it can explain why the SCC increases, because of the mixing of pathogens at the time of contact between the animals.

Milk sampling and analysis:

Milk samples were taken during milking directly from the milking machine, and teat samples were taken by hand for each goat. Samples were taken by farmers themselves or by TINE advisors. Milk samples were analyzed in the NMBU laboratory at As (Norway), and teat samples were analyzed at the TINE Mastitis Laboratory at Molde (Norway).

Processing of analysis results:

Farms were analyzed independently: it was easier to organize because results were received from the laboratories on different dates.

Received data from laboratories were organized in a dataset in Excel for each farm, where all the goats were listed with their milk results. Thanks to these datasets, statistical analysis was done in the RStudio software and thanks to the XLSTAT (by Addinsoft) software for Microsoft Excel.

For each farm, the main dataset was divided into three small ones: "CompareSCC" where the SCC of each goat on the three periods (seasons) were grouped, "CompareBacteria" where the bacteria count of each goat on the three periods were grouped, and finally "CompareTeatBac" where each combination of bacteria has been assigned to a number (code) to compare periods.

The variables of the datasets "CompareSCC" and "CompareBacteria" were quantitative variables, but the ones of "CompareTeatBac" was categorical. That means that not the same statistical tests were used for the three criteria. For the two first ones, a Pearson correlation test (cor.test) was used, to know if there was a correlation between periods, and if yes, in which direction the correlation was. These tests permitted to know if the grazing period and the heat/mating period correlated with the somatic cell count and the bacteria count of the goats.

For the variable "CompareTeatBac" which was categorical (qualitative), a Khi-2 (chisq.test) test and an Anova test were used (with linear regression) to know if there was a correlation between periods, or if periods were independent of each other. This test permitted to know if the grazing period and the heat/mating period correlated with the different combinations of bacteria found in the udder, and if some combinations were more present than others depending on the season.

For the part of the impact of parity on the SCC and bacteria count, firstly the year mean of SCC and bacteria count was done for each goat where all three periods were combined, which was called "MeanSCC" and "MeanBacteria". Secondly, a variable "Parity" was created where the parity of each goat was mentioned. After that, an Anova test took place (with linear regression) between the variable "Parity" and the variables "MeanSCC", and "MeanBacteria" to see the correlation between the year mean of each goat and their parity. These results showed how the parity impacts the somatic cell count and the bacteria count, and if these criteria worsen with the age and therefore the parity of the goats.

3. Chapter 3: Results

The data from the nine farms were collected, organized, and finally analyzed using statistical tests such as Pearson correlation tests and linear regressions. Potential correlations were observed with the seasons and the parity of the goats and this made it possible to measure the impact of the season and, parity, and bacteria strains factors thereafter.

3.1. Impact of the season on the SCC and bacteria count

- **SCC**

The literature review and the statements of the farmers and TINE advisors highlighted the impressive growth of somatic cells and bacteria in the milk during the summer. The nine chosen farms reflect these phenomena as shown in figure n°1 below. It is easy to see the increase of somatic cell count during summer for almost all the farms, except for OST4 where the increase is when goats are going back to the barn.

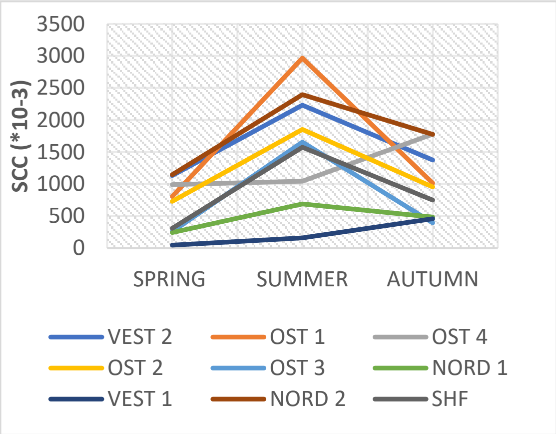

Figure n°1: SCC evolution over the seasons

To measure the impact of the seasons on the somatic cell count, an Anova test took place, including a linear regression. The means of each farm and for each season were tested. The result, in the table n°2 below, shows for the SCC an R^2 coefficient of 0,288 and a P-value of 0,02 (below 0,05). It means that the result is significant thanks to the p-value below 0,05 and that almost 30% of the variability of the somatic cell count is due to and explained by the seasons. Thanks to this statistical test, it is now possible to affirm that the seasons have a significant impact on the somatic cell count of Norwegian goats.

Table n°2: Linear regression result for the impact of the seasons on the somatic cell count and bacteria count

	Coefficients	Values	Results	Interpretation
SCC	R^2	0,288	28%	
	P-value	0,02	<0,05	Significant
Bacteria count	R^2	0,234	23%	
	P-value	0,069	>0,05	Non significant

- **Bacteria count**

For the nine chosen farms for the study, this phenomenon is less impressive than the somatic cell count evolution with the season, but it is visible in the figure n°2 that farms generally have a higher bacteria count during summer, except OST2 which starts with a very high count in spring and decrease over the year.

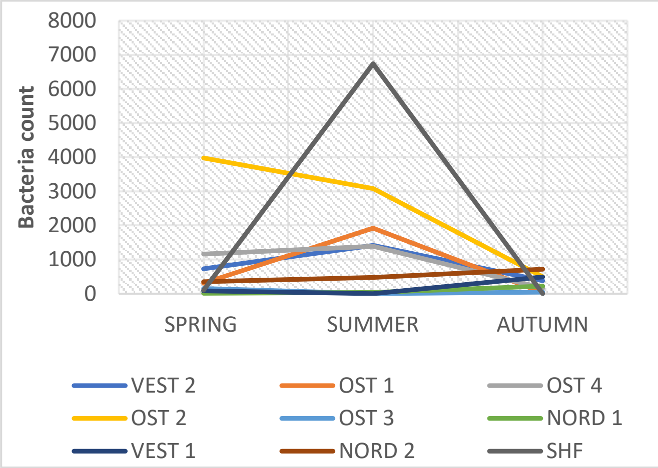

Figure n°2: Bacteria count evolution over the seasons

As described before for the somatic cell count, an Anova test took place, including linear regression, to look at the impact of the seasons on the bacteria count in Norwegian goat milk. For that the bacteria mean of each farm and for each season were tested. As shown in table n°2, the R^2 coefficient is 0,234 and the P-value is 0,069. It means that according to the statistical test, the variability of the bacteria count can be explained at 23% by the seasons, but the P-value is above 0,05, which means that this result is not significant. The value is quite close to 0,05 which could imply that even if the result is not significant, it is still quite correct. This would allow admitting that the seasons certainly influence the bacteria count.

- **Correlation between somatic cell count and bacteria count**

It was interesting to know if the somatic cell count and the bacteria count were correlated, to know if, for example, if the bacteria count decreased, the cell count will follow it or not. A Pearson correlation test then took place for each season to look at it. The results are in table n°3 below. As it is written, the correlation coefficient is not above 0,5 and so close to 1, which means that the correlation between somatic cell and bacteria count is moderated but still there. For all the seasons the result is quite the same, which means that no matter what time of year if one goes up or down, the other will follow.

Table n°3: Correlation between somatic cell count and bacteria count depend on each season

Seasons	Mean coef. Cor.	Result	Interpretation
Spring	**0,374476544**	0,3<x<0,5	Moderate positive correlation
Summer	**0,3714375**	0,3<x<0,5	Moderate positive correlation
Automn	**0,370471159**	0,3<x<0,5	Moderate positive correlation

3.2. Impact of the parity on the SCC and bacteria count

The second step of the research is to look at the impact of the parity on the somatic cell count and on the bacteria count of the goats.

- **Impact on the SCC**

According to the literature, the parity seems to be one of the factors influencing the quality of milk. On the nine farms in the study, as shown in figure n°3, the average somatic cell count seems to increase gradually until the 4^{th} parity and to stay on a fairly high SCC for the following years. Only two farms had goats in parity nine and ten, so these results are not significant.

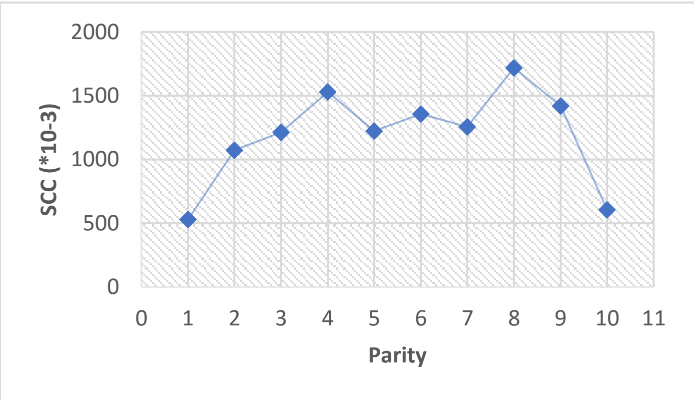

Figure n°3: Mean of the somatic cell count depend on the goat's parity

Table n°4 described the result of the correlation test (Pearson) between the parity of the goats and their somatic cell count. As this correlation coefficient is under 0,3, it means that the correlation is low, but there is one. With a linear regression is it possible to know how much percent of the variable "SCC" can be explained by the variable "Parity". As shown in figure n°9, the R^2 coefficient is 17,4%, which means that a bit more than 17% of the variability of the somatic is explained by the parity of the goats.

Thanks to these two statistical tests it is now possible to say that there is a correlation between the parity and the somatic cell count, and the parity explains almost 20% of the variability of the somatic cell count in the nine goats herd of the study.

Table n°4: Correlation and linear regression between the year SCC mean and bacteria count mean with the parity of the goats

	Coefficients	Values	Results	Interpretation
SCC/Parity	Correlation coefficient	0,27367428	0<x<0,3	Weak correlation
	R^2	0,174	17%	
	P-value	0,04	<0,05	Significant
Bacteria count/Parity	Correlation coefficient	0,001113447	0<x<0,3	Very weak correlation
	R^2	0,057	6%	
	P-value	>1	>1	Non significant

- **Impact on the bacteria count**

For the impact of the parity on the bacteria count, a mean of all the farms would not be representative because of the farm SHF and OST 1 which have very high results compared with the other farms. But the figure n°4 shows that all the other farms seem to have very varied results and no tendance can be identified.

Excepting SHF and OST1, all the other farms stay between 0 and 2500, no matter the parity.

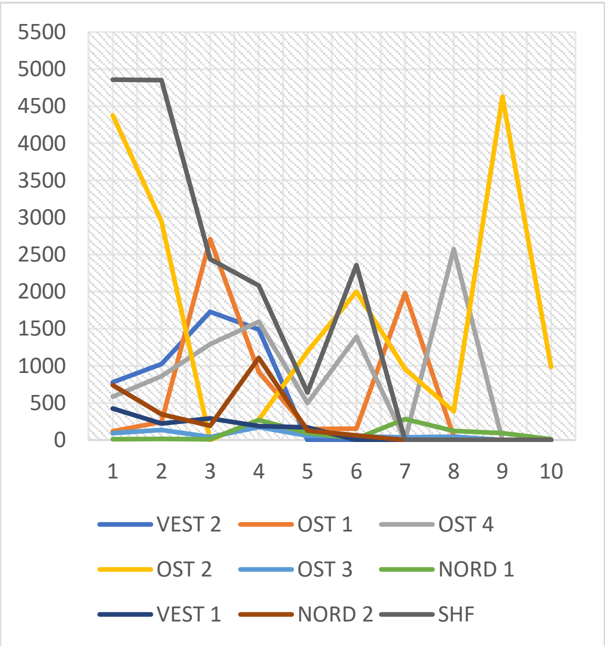

Figure n°4: Bacteria count depends on the goat's parity

Table n°4 describe the result of the correlation test (Pearson) between the parity of the goats and their bacteria count. As this correlation coefficient is under 0,3 and very close to 0, it means that the correlation is very low. With a linear regression it is possible to know how much percent of the variable “BacteriaCount” can be explained by the variable “Parity”. As shown in table n°4, the R^2 coefficient is 0,057, which means that only 6% of the variability of the somatic is explained by the parity of the goats, as the p-value is above 0,1 so this result is not significant.

Thanks to these two statistical tests it is now possible to say that there is no correlation between the parity and the bacteria count and that there are certainly other factors that impact the bacteria count of goats.

3.3. Impact on the type of bacteria

The third step of the research is to look at the type of bacteria and if it is impacted by the seasons and the parity, which could explain the increase of somatic cell count and bacteria count at certain periods of the year or at a certain age.

For this part of the research, a number has been attributed to each combination of bacteria (Left side/Right side of the goat’s udder), a table with all the combinations with their number is available in appendix n°1.

- **Impact of the seasons**

As shown in figure n°5 below, the most present combination in all seasons is the n°1 (Negativ/Negativ), so it is the negative goats, the ones who are not infected by any bacteria according to the lab. After that, the main other combinations that are present in all the seasons are the n°2, 3, 4, and 17.

The combination n°2 is Negativ/*S.aureus*, the n°3 is Negativ/*S.warneri*, the n°4 is Negativ/*S.caprae* and the n°17 is Negativ/*S.epidermidis*. The other combinations are much more less present and the differences are not significant between seasons.

In the four main combinations, there are four strains of bacteria: *S.aureus, S.warneri, S.caprae,* and *S.epidermidis*. As shown in figure n°13, the differences between seasons for each combination is not significant, it is not possible to assume a certain tendency.

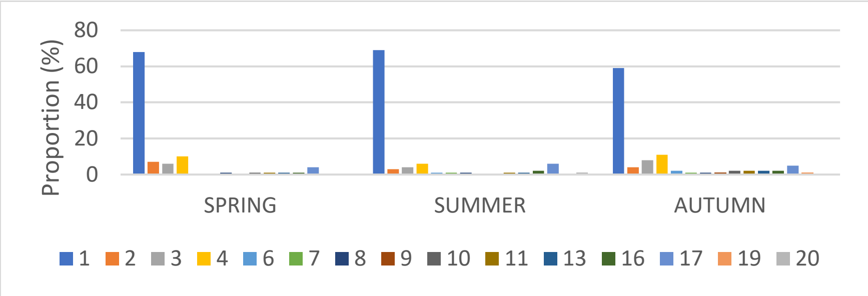

Figure n°5: Proportion of bacteria combinations for each season

- **Impact of the parity**

As seen before, a few bacteria strains seem to be more present: *S.aureus*, *S.warneri*, *S.caprae*, and finally *S.epidermidis*. In figure n°6 below, these four main bacteria strains are still here. On this graphic, the proportion of each bacteria for each parity is shown. It is visible that the number of infected goat by *S.aureus* (Negativ/*S.aureus*) seem to increase after parity 4, and, for a second time, the graphic also shows that *S.epidermidis* is more present after parity 8. On the other hand, *S.caprae* is quite stable over the parities. However, *S.warneri* seems to decrease after the parity 4.

Finally, it is hard to see a real tendency for the bacteria strains on the nine farms even if some results seem to be relevant. In a general way, the number of Negativ/Negativ goats is decreasing over the parity, and some "main" bacteria are getting to amplify after a few parities like *S.aureus* for example.

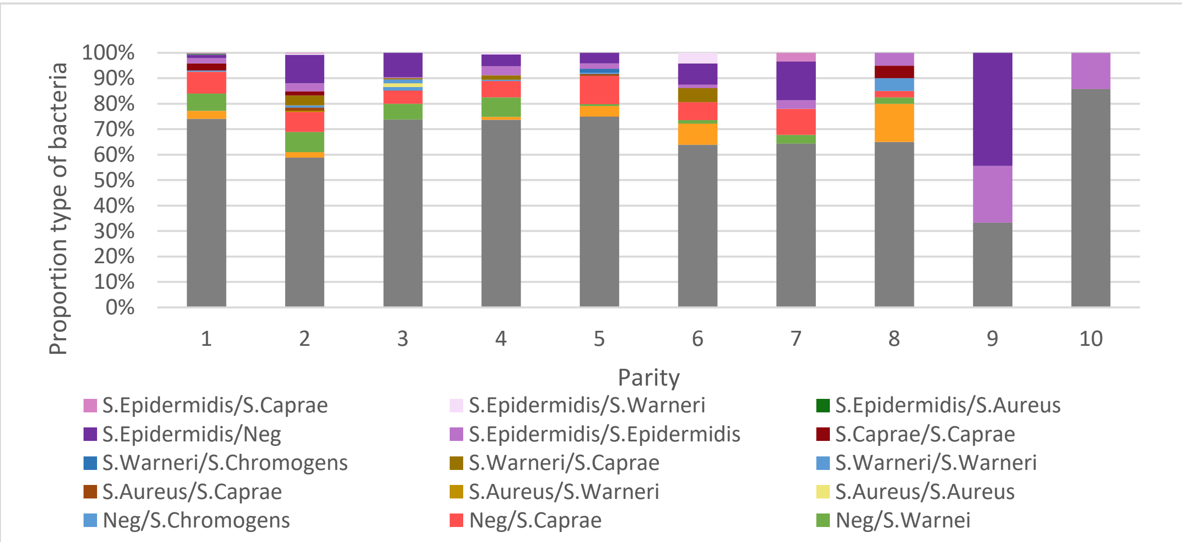

Figure n°6: Proportion of each bacteria combination for each parity

- **Influence of bacteria strains on the bacteria count**

Thanks to a linear regression, it is possible to measure the impact of bacteria strains on the bacteria count. As described in table n°5, the coefficient R^2 shows the part of the variable "bacteria count" that is explained by the type of bacteria. This coefficient varies greatly from farm to farm, making interpretation difficult. Finally, it is not possible to give a universal result on this criterion, each farm has too different results. So it is not possible to say that the type of bacteria really influences the bacteria count, even if it is possible to suppose it since a majority of the farms have a rather high R^2.

Table n°5: R^2 coefficient between the bacteria strains and the bacteria count

Farms	**R^2**
Vest 2	19,3
Ost 1	42,8
Ost 4	6,2
Ost 2	14,5
Ost 3	7,2
Nord 1	21
Vest 1	16,2
SHF	2,6

In figure n°7 below, the average bacteria count for each bacteria combination is shown. Thanks to that, it is possible to see which bacteria induce the most increase in the bacteria count. It is then visible that the numbers 1,2,8, and 17 are associated with the biggest bacteria count, and the numbers 4, 6, and 7 are the second ones.

The number one is the combination Negativ/Negativ, which means that even the negative goats, the ones where no bacteria strains were found, have a high bacteria count, so it is not the bacteria strains that induce the bacteria count. The number 2 is the combination Negativ/*S.aureus*, this bacteria is very famous for its capacity to cause mastitis. The number 8 is the combination S.Aureus/S.Caprae and the 17 is the combination Negativ/*S.epidermidis*. For the other numbers that seem to have a fairly high bacteria count, there is the number 4 (Negativ/*S.caprae*), the number 6 (*S.aureus/S.aureus*), and the number 7 (*S.aureus/S.warneri*).

Finally, the bacterias strains of *S.aureus*, *S.caprae*, and *S.epidermidis* generally seem to induce an increase in bacteria count.

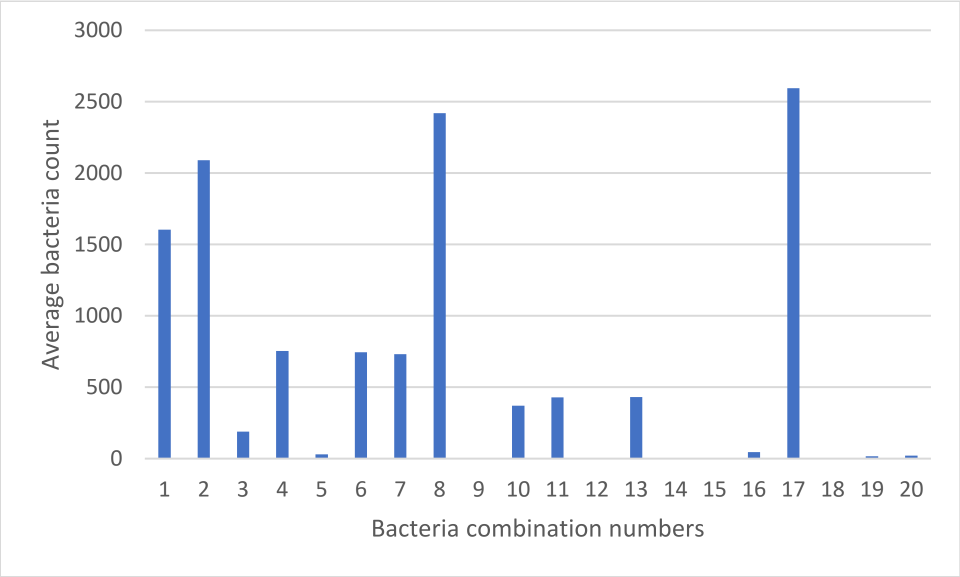

Figure n°7: Average bacteria count for each bacteria combination

3.4. Questionnaire

The questionnaire approached different factors which could influence the result of the study. It has been useful especially for the factor "Seasons" thanks to the answers of farmers. On the nine farms in the study, three didn't answer it, so only six farms gave answers. The list of questions can be found in Appendix n°3.

In terms of results, half did grazing at Stol (mountain pasture during summer), and the other half did grazing at home pasture. For the ones who are going at Stol, they drive goats in a truck, for other ones, they are going to the pasture by walk. In the three farms that are going in the mountain pasture, one shares the pasture with other herds, so herds are mixed during the summer period. For all farms, pasture altitude is between 600 and 800 m, and only one farm is at 250m of altitude. Whether it is farms in the mountains or goats grazing at home pasture, they always have indoor access at night. Milking is done in a milking stall or in a traditional way (for 2 farms). Five farms on the six assume to not see any sign of stress (fighting, biting, aggressive behavior), and one said that he saw fewer signs of stress during the grazing period. Half of the farms put the bucks on pasture with the goats, and the mating season starts in September or October depending on the farm. Farms affirmed that no special events appear during the summer period, like wolf attacks or tourist issues which could increase the stress in the herd. For the inside period, when goats are in the barn, they have about 1,5 m^2 per goat and between 4 and 18 drinking vessels/nipples depending on the farm and herd size. Finally, the majority of the farmers use milk control to manage their cell count, by culling or treating goats that have a high cell count for example.

4. Chapter 4: Discussion

Milk and teat samples from the nine goat farms were analyzed in a lab, and results were sent to the R&D department of TINE. These results were used to make statistical analyses, mainly with correlation tests and linear regressions. The goal was to look at the potential correlation between the seasons and the parity and the somatic cell count and bacteria count in goat milk, but also to look at the different bacteria strains present. Thanks to this study, main results have shown that seasons and parity influence the somatic cell count and that the bacteria count was really less correlated with all factors.

4.1. Discussion of the method

The study went as planned and according to schedule. Somatic cell count and bacteria count were analyzed from milk samples in food analysis laboratories. The techniques used are supposed to be adapted to goat milk and to be different from the techniques used for cow milk. However, some researchers involved in the project seem to think that the technique used to define the bacteria count was not adapted and does not to give a result corresponding to the real bacteria count of the milk, it seems to be biased. Nothing really proves this at the moment, it is only a guess but it is necessary to underline this. Indeed, usually the bacteria count is given thanks to an individual analysis in sterile cups and machine, but for this study they did the bacteria count analysis at the same time and in the same machine as for the SCC and milk component, so not in sterile cups. This not usual technic was used to try it but it seem to not be a good one. On the other hand, the somatic cell count and the teat samples seem to be representative of reality and the analysis techniques used seem to be adapted.

4.2. Correlation between SCC/Bacteria count and seasons

The method used for this question was quite effective. Three farms on the nine did not have the bacteria count analysis done for all the 3 seasons, which means that the study did not have complete results for 3 farms on the 9 to compare the bacteria count. The second bad point is that it would have been better to sample at exact dates, for example, 15 days before grazing for the spring season, 3 weeks after the start of grazing for the summer season, and 3 weeks after the return to the barn for the fall season. This would have provided even more reliable results. Indeed, the samples here were done in a time slot but each farm did "what it could" from an organizational point of view, so the sampling dates are a bit scattered and this could alter the results.

Regarding the results, the statistical test permitted to look at the effect of the seasons on the somatic cell and bacteria counts. It appeared that the somatic cell count was significantly impacted by the seasons since 30% of the SCC variability could be explained by this "seasons" factor. On the other hand, the bacteria count did not correlate significantly with the seasons, although it was not far off. Finally, it was seen that the somatic cell count and the bacteria count were correlated, and this in each season, which means that their increase and decrease follow each other.

The literature seen previously is accorded to our results. Indeed, previous studies have shown that the somatic cell count and the bacteria count evolve with the seasons, the study can show this same phenomenon in the Norwegian goat herd. For the summer season, where the cells tend to increase strongly, several tracks are possible to explain it. As seen in the study of Granado in 2014, it can be due to stress (whatever it is), diet, hygiene, or to heat (sun exposure). Thanks to the questionnaire that the farmers answered, it was possible to notice that the majority of the farms took their goats up the mountain in trucks or trailers to bring them to the summer pasture in the mountains. This transport is very stressful for the animals and it could explain in part the increase of the SCC during this period. All farms in our study provided access to indoor space night and day even during the grazing period, which excludes heat stress from potential causes. Indeed, if the goats were too hot in the sun outside, they could go inside to cool down, but they do not. Concerning hygiene, it could be rather problematic during the period in barn because of the litter in particular. In our farms, there is a minimum of 1,4 m² per goat which is big enough not to overcrowd the building and therefore not to have bad hygiene, so it is possible to exclude this cause as well. Finally, it has been noticed that goats in high-altitude pastures had more cells than the others on average on the 9 farms studied. This could be explained by the change in diet as indicated in the literature by the study of Granado in 2014, since the plant species in lowland pastures are not the same as in the mountains. Some of the studied farms put bucks with goats in pasture, this method can increase the somatic cell count according to the study of Granado but also the one of McDougall in 2002 which showed that the hormones can induce an increase of SCC when bucks are with goats.

Finally, the results from the nine Norwegian goat farms are quite consistent with the results found in the literature, applying the Norwegian breeding model and it is possible to say that the seasons have an impact on the SCC and the bacteria count, especially the summer.

4.3. Correlation between SCC/Bacteria count and parity

It was possible to collect the parity of each goat for each farm thanks to the Herd recording system. This allowed having large enough samples of goats for our results to be meaningful and representative. This question was conducted as foreseen in the original plan. The point to improve would be, as said before, to have the results at each season for each farm. Indeed, three farms missed at least one season, which reduces the sample size.

Regarding the results, the statistical tests permitted to look at the correlation between the parity and the somatic cell and bacteria counts. For the somatic cell count, the Pearson correlation test showed a correlation of 0.27 was present, which is almost a moderate correlation. And the linear regression affirmed this with an R^2 coefficient of 0.18, which proves to that 18% of the variability of the SCC is due to the parity of the goats. For the bacteria count, on the other hand, the Pearson test shows a very weak correlation, almost non-existent with parity. This is confirmed by the linear regression test which shows that only 7% of the variability of the bacteria count is explained by parity, but also that this result was not significant.

With a comparison between our results and the literature, it is possible to say that it is quite heterogeneous. Indeed for the SCC, it is consistent, it seems to increase with the parity of the goats as indicated in the study of the University of Ilorin, seen previously, where the third parity goats had a triple somatic cell count than the primiparous. On our 9 farms, this is more obvious between the 1st parity and the 4th where it is easy to see that the SCC doubles or even triples as was shown in figure n°3 previously. After the 4th parity, the results fluctuate a little and do not follow any trend, but the SCC remains high. On the nine farms, only one didn’t have goats with more than four parities, which means that all the other ones keep their goats until 6 or 8 eight parities, which could increase de somatic cell count mean of the farms. The study by Ysuff (et al.) in 2021 also said that udders get damaged with age and become more prone to infections, on the goats of the 9 farms studied, it was not noticed any damaged udders due to milking or age, so this criterion does not seem to be a cause in our case.

On the other hand, for the bacteria count, the study of the company TINE by Smistad in 2021 where the results of ten years were taken into account, said that it had a tendency to decrease with the parities, as the 6 and 7th parities goat had two times fewer bacteria cells, however, on our 9 farms studied this is not the tendency. Each farm has quite large fluctuations of bacteria count depending on the parity of the goats and no trend is possible to notice. The study of Ysuff in 2021 states that primiparous goats are the healthiest and that with age and parity, the goats become more and more infected. This was explained by the fact that with time the udder became a kind of reservoir for bacteria, and that the annual drying off was not enough to eradicate all bacteria. So here it is not possible to say which answer is the good one because none of them is comparable with the study results.

In the end, our results seem to agree with the literature in relation to the somatic cell count, but the bacteria count of our 9 farms does not seem to follow the same directions as previous studies from other countries. The search for the causes of the Norwegian results will therefore have to continue.

4.4. Factors influencing or not the type of bacteria

For this question, teat samples were done for each goat of all of the nine farms and these samples have been analyzed in a laboratory. These samples were done by hand either by the farmer or by the TINE advisor, which can explain why it is not possible to be sure about the sanitarian condition when samples were taken. This factor may be a bias to our results. Indeed, if the people who took the samples by hand did not have clean hands, bacteria may have been mixed and transmitted from one goat to another. However, the total number of goats still allows for having enough individuals for our results to be representative enough to use in our research. The assignment of a code for each bacterial combination allowed an easier study of the results in statistical programs.

- **Impact of the seasons**

About the impact of the seasons on the type of bacteria present in the milk of the 9 farms in the study, the first thing possible to see is that there is a majority of Negative/Negative goats, and fortunately, this is normal, it means that the majority of goats are healthy. Next, it is easy to see that four main bacteria are present: *S.aureus*, *S.warneri*, *S.caprae*, and *S.epidermidis*, as it was mentioned previously in the study of Taufik in 2008. These bacteria are present in all seasons and there is no significant difference between them.

It is not possible, therefore, to affirm that there is a link between the seasons and the type of bacteria. The graph shows that these four bacteria remain in the udders of the goats all year round, but do not develop particularly at a certain period. This means that there does not seem to be a link between the type of bacteria and all the factors associated with the seasons, i.e. environment, humidity, or feed. In the document of Bernier-Gosselin in 2021 seen previously, the "environment" factor seemed to be important when it comes to the type of bacteria found in milk, for example, *S.aureus* is found in dirty and humid environments. As there is no peak of *S.aureus* in a certain season, this could show that the environment of the goats is, in every season, healthy and clean enough for some bacteria to explode. The nine farms of the study were quite different in management so they are quite representative of all the dairy goat farm systems possible to find in Norway. It is possible to say that the period does not influence the type of bacteria in Norwegian goat herds.

- **Impact of the parity**

For the parity, as perceptively there is a majority of Negative/Negative goats at all ages, which is normal and reassuring for the nine farmers. The four bacteria seen just before are still predominant at each parity. But when you look at the graph, it is difficult to really see a result. Indeed, no trend is possible to determine, the results are quite varied and are difficult to explain.

To begin with, *S.caprae* is always present, but it remains stable over time. Then *S.epidermidis* seems to increase after parity 8, but *S.warneri* seems to decrease after parity 4. As for *S.aureus*, it increases significantly after parity 4.

According to Bernier-Gosselin in 2021, *S.aureus* and *S.caprae* are bacteria found in the environment, while *S.epidermidis* and *S.warneri* are "normal" hosts present on the skin of goats. Our results do not really correspond to this since *S.epidermidis* tends to increase while *S.warneri* tends to decrease, whereas they should rather go in the same direction. It is not possible to say that the skin's pathogens decrease or increase with the years as our results are contradictory. On the other hand, the fact that *S.aureus* increases with age could be explained in the following way: this bacteria strain is considered as a major pathogen, particularly aggressive, and goats could become more and more sensitive to this pathogen with time as if their immunity loses efficiency with age and would have difficulties to counter this infection.

In general, these results are not significant and it is not possible to assert anything thanks to them, simple suppositions are only possible.

5. Chapter 5: Conclusion and recommendations

5.1. Conclusion

For some years, the Norwegian dairy goat sector is confronted with somatic cells and bacteria issues in goat milk. All the actors in this sector, farmers, advisors, and dairy companies, want to solve this issue. This issue induces a loss of money for farmers because the somatic cell count is the base of the payment grid, but it is also an issue for cheese making because of the loss in quality. To solve this issue, nine Norwegian goat farms have been studied in 2022 to look at the correlation between somatic cell count, bacteria count, seasons, and parity.

Milk analysis from laboratories was received and used to make statistical tests to know the different correlations. The seasons seem to explain 30% of the variability of the somatic cell count and summer makes it double or even triple. For the bacteria count, seasons seem to explain 23% of its variability, but this result is not really statistically significant. In a general way, yes seasons have an impact and especially summer which makes it increase a lot.

About the parity, it seems to explain 18% of the somatic cell count variability, but there is no correlation with the bacteria count. The somatic cell count increase with the number of parity until the 4^{th}, and becomes stable while remaining high after the 4^{th} one.

The type of bacteria strains is not influenced by the seasons and the parity according to the statistical analysis.

In a general way, somatic cell count is particularly influenced by seasons and parity, with a total of almost 50% of its variability explained by these two factors. However it is not really the case for the bacteria count, but researchers have doubts about the techniques used in laboratories and their accuracy. In the “season” factor, it is possible to include, the environment, the feeding, the heat period, or the stress due to the transport to the pasture. Further scientific studies could clarify these results.

5.2. Recommendations

This study has provided results that will be useful for farmers and other stakeholders in the goat sector in Norway.

Starting with the results on goat parity and its influence on milk cell count, it has been seen that on the nine farms studied, almost all the farms kept goats after 4 parities and more than half kept goats above six parities. By keeping goats above four parity, farmers take the risk of increasing their somatic cell count in their milk tank. Farmers should perhaps decrease the average age of their herd, and make a selection at the 4th parity, the goats that have a too high SCC must be culled to be replaced by young healthy goats. To be even more precise on this criterion, the same study but extended to other farms could be done. This would allow having an even more significant result by using the results of about fifty farms.

About the Season's results, they show that they influence the somatic cell count and explain about 30% of its variability. However, our study does not allow to differentiate between these potential causes and determine which are the most prevalent. In order to prevent this exponential increase in somatic cell counts during the summer, it might be interesting to start by trying to reduce as much as possible all potential sources of stress for the goats, such as walking to the pasture instead of driving to it, or mixing the herds progressively to avoid conflicts. Another possibility would be to try to avoid mixed herds to avoid mixing bacterial germs and transmitting them from one herd to another.

Further studies would be necessary to give a more complete answer to farmers and other stakeholders in the goat industry. These next studies should target the summer period in pasture and analyze the behavior (stress), blood samples could also be taken to look at the level of hormones and if it is correlated with the increase of SCC, and finally compare the results between herds that remain alone in a pasture with herds mixed with others during this period. This could be done on a dozen farms like our study.

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Appendices

Appendix 1: Number code attributed to bacteria's combinations

Combinations		Code Number
Negativ	Negativ	1
Negativ	S. aureus	2
Negativ	S. warneri	3
Negativ	S. caprae	4
Negativ	S. chromogens	5
S. aureus	S. aureus	6
S. aureus	S. warneri	7
S. aureus	S. caprae	8
S. aureus	S. chromogenes	9
S. warneri	S. warneri	10
S. warneri	S. caprae	11
S. warneri	S. chromogens	12
S. caprae	S. caprae	13
S. caprae	S. chromogens	14
S. chromogens	S. chromogens	15
S. epidermidis	S. epidermidis	16
S. epidermidis	Negativ	17
S. epidermidis	S. aureus	18
S. epidermidis	S. warneri	19
S. epidermidis	S. caprae	20
S. epidermidis	S. chromogenes	21

Appendix 2 : sources of the data used for the study

		Data from :		
		Milk samples	Teat samples	Norwegian Herd Recording System
Criteria/Indicator	SCC	X		
	Bacteria count	X		
	Bacterias denomination		X	
	Parity			X

Appendix 3: List of selected questions from the questionnaire

Questions
Type of pasture
Type of transport to the pasture
Common/shared Støl (croft) pasture (more than one herd)
number of meters from lowest to highest location on pasture (mountain/støl pasture) = difference of altitude (in meters)
Access to indoor housing at night time during the pasture period (støl)?
Type of system for milking (støl)
Access to indoor housing at night time during the pasture period (home fields)?
Do you see more signs of stress (for example biting, fighting and aggressive behavior) in the goats during the grazing period than otherwise?
What do you do before grazing to keep the cell count down? (Several choices possible)
Were there special events during the grazing season this year that could explain the sudden rise in tank milk cell numbers? State the approximate date and event. Judgment: 6/6 A herd of cows/dogs/tourists scared the goats 29-...
Pairing (multiple choices possible)
How big is the indoor area (number of square meters) per adult goat? (estimate total pen area divided by the number of adult goats)
Type of system for milking at home
Does the kid go with the herd during the grazing period?
What do you think are the best measures to control the cell count during the grazing and estrus periods?