Gene expression: Nguni and Bonsmara cattle

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A gene-expression study on the growth performance of Nguni and Bonsmara cattle grown in a feedlot fed a high and low energy diet.

Industry Sector: Cattle And Small Stock

Research Focus Area: Livestock Production With Global Competitiveness: Breeding, Physiology And Management

Research Institute: Agricultural Research Council

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Researcher: Dina Linde

The Research Team

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Executive Summary

Introduction

In South Africa, Nguni cattle are one of the breeds found predominantly in extensive production systems. The Nguni is an indigenous cattle breed and is widely used in crossbreeding systems due to their high fertility and mothering ability. Nguni cattle are also commonly used in communal production systems. The majority of beef in South Africa is produced in feedlots using commercially formulated high energy diets, where preference is given to medium and large framed later maturing cattle that include British types and composites such as the South African Bonsmara. Due to the Nguni's small frame and low meat yield when compared to British types it is nor preferred as a feedlot animals, however studies have shown that Nguni cattle produce high quality meat. The veldt of South Africa has a varying degree of carrying capacity, however the occasional drought conditions have necessitated the use of alternative production systems such as feedlots for finishing cattle. The use of a lower energy diet in feedlots for indigenous cattle have been suggested and warrants investigation. Nutrigenomics is the study of the effect of nutrition

on the genes of the animal by quantifying the gene expression. An improved understanding of the interaction between the nutritional environment and the genetics of the animal can lead to increased efficiency and production. Diets that are different in components or ingredients can result in different phenotypes in the animals. In this study the effect of two feedlot diets with different energy levels have been investigated using a transcriptome approach.

Objective Statement

The objective of this study is to determine if there are gene expression differences between Nguni and Bonsmara cattle fed a low or a high energy diet. The gene expression of the cattle can determine the underlying differences in the reaction of the two breeds to the two different diets.

Project Aims

1. To evaluate whether the Celtic mutation on the POLL locus is the causative mutation for polledness in Bonsmara and Drakensberger
2. To perform a genome wide association study of the Polled and Scur genes based on phenotypic data and genotypic data from the GGP Bovine 150K SNP bead chip
3. To apply sequence data available from the Bovine Genomics Program to finemap the suspected regions for the Polled and Scur genes

Results

Performance results showed a higher live weight, carcass weight and marbling score for all bulls fed the high energy diet compared to bulls fed the low energy diet. Only carcass weight and marbling score had significant difference in terms of diet ($p < 0.05$). Live weight, average daily gain, rib fat, rump fat and eye muscle area were only significant for breed. Diet had a greater effect on the Bonsmara compared to the Nguni according to transcriptomic and phenotypic values. Transcriptomic values showed 3584 differential expressed genes (DEG) between the Bonsmara fed the two different diets, while only a difference of 288 DEG were observed between the Nguni fed the two different diets. Phenotypic values show a difference of 20 kg between the Bonsmara groups and only a 6 kg difference between the Nguni groups. Most DEG were involved with cellular processes and metabolic pathways. A total of 73 differentially expressed genes were observed between the diets across breeds. The genes that were involved in intramuscular fat deposition (CRHR2, NR4A3, MMD) were expressed on a higher level in the bulls on the low energy diet compared to bulls on the high energy diet. Genes that were involved in muscle deposition (PITX2, Leptin, AVP) was expressed higher in the bulls on the high energy diet. Comparing the breeds revealed that 2214 genes were differentially expressed between the Bonsmara and the Nguni. At the end of the feedlot trial a higher expression of marbling genes (SIRT, ND, ADIPOQ) were observed in the Nguni, however this expression was not observed in the marbling scores recorded. Several genes (ASIP, MOGAT, SNAI3) that were involved in fat deposition were upregulated in the Bonsmara. This suggests that the Nguni was still growing at the end of the feedlot trial while the Bonsmara had reached physiological maturity. Little literature could be found on some of the gene showing the highest expression in the groups such as GSTA3, TEX28 and TUBB3. Glutathione-s transferase alpha 3 (GSTA3) is linked to steroidal genesis and could therefore have an influence on myogenesis, however no confirming literature could be found.

Conclusion

The diet had a smaller effect on the Nguni bulls compared to the Bonsmara bulls as observed in the DEG and the carcass weight of the bulls. This might indicate that the Nguni is more adaptable to a variation in feed quality. The Bonsmara bulls had a higher meat yield on the high energy diet, however it seems as if the bulls on the low energy diet had a higher expression of the marbling genes. This is in contrast to the phenotypically higher marbling score. Further research needs to be done as this study had a small sample size (n=40). An extended feedlot period for Nguni cattle should be considered in future studies. This study provides reference data for differentially expressed genes in muscle of South African feedlot cattle.

Popular Article

A low energy feedlot diet may favour our indigenous breeds

Dina Linde[1,2], Michiel Scholtz[1,3] & Este van Marle-Koster[2]

Introduction

The phenotypes of animals vary due to differences in their genetics and environment. The expression of the genes of animals can also be influenced by their diet. In South Africa, Sanga cattle (Afrikaner and Nguni) are adapted to various environments and production systems. However, these cattle are mostly found in extensive production systems that make use of natural grazing. They are not preferred in the feedlot, as their smaller frame sizes compared to *Bos Taurus* types and crossbreds will lead to smaller carcass sizes. The traditional diet fed in the feedlot is a high energy diet, that includes maize and maize by-products. There are however, farmers that believe that a high energy diet does not suite the genetics of Sanga cattle and that these breeds would do better on a lower energy diet.

A study was done to find alternative strategies for Sanga cattle in the feedlot. A diet low in energy (10.9 MJ ME/kg) or a high energy diet (12.5 MJ ME/kg) was fed to Nguni and Bonsmara cattle for a period of a 120 days respectively. During the feeding period the animals were weighed and real time ultrasound scanned for meat quality characteristics such as eye muscle area (EMA). At slaughter, muscle samples were taken to analyse the gene expression data.

In terms of the feedlot data, no significant difference could be found between the diets with regard to live weight, eye muscle area (EMA), rib fat and rump fat in the Nguni. Breed differences were however found. Carcass weight and marbling did however show significant difference as well as an interaction between breed and diet.

Breed had a much bigger effect compared to diet, with 2214 differentially expressed genes (DEG) and 74 DEG, respectively. Of the genes found differentially expressed between the breeds, several genes known to be involved in marbling (SIRT, ND, COX, ADIPOQ, SERPINF2) was expressed higher in the Nguni compared to the Bonsmara. However, the phenotypic marbling score was higher in the Bonsmara compared to the Nguni.

This lead to the suggestion that the Nguni needed more time (a longer feedlot period) for the expression of the marbling genes to show phenotypically. This is in contrast to the industry that perceives that the Nguni deposits fat too early in comparison to exotic and crossbreds. Sanga cattle tend to first deposit fat intramuscularly, which might be an adaptation mechanism for the harsh conditions in which these cattle lived. It seems, however, that the Nguni only begins depositing muscle tissue after a sufficient layer of fat is deposited. This might be the reason for backgrounding, which is common practise in the Nguni breed.

Between the Nguni fed the high energy diet and the Nguni fed the low energy diet, 288 genes were differentially expressed. The different levels of energy in the diets seem to result in different components being deposited. Various genes (PITX2, PAX, Leptin, AVP, OXT) involved in muscle deposition were upregulated in the bulls that received the high energy diet, compared to the bulls fed the low energy diet. This is also seen in the phenotypic results with the carcass weight of the bulls fed the high energy diet being higher compared to the bulls fed the low energy diet.

The difference in carcass weight is very small between the Nguni fed the high energy diet and the Nguni fed the lower energy diet (6 kg). However, genes that influence intramuscular fat deposition (SPARC, CRNR2, CHRND, NR4A3, MMD) were elevated in the bulls that received the low energy diet compared to the bulls that received the high energy diet. This was also not shown in the phenotypic traits. Extending the period of feeding may result in the bulls that received the low energy diet to express the phenotype.

It seems that the low energy diet suite the Sanga cattle better, when compared to the traditional high energy diet fed in the feedlots. This should be further investigated as this study had a relatively small sample size (n=40). Furthermore, as these animals are ruminants, it would be also interesting to study the rumen microbiome in another study of this kind.

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Footer And Tags And Categorisation

Please contact the Primary Researcher if you need a copy of the comprehensive report of this project on : – mmakgahlela@arc.agric.za

Breeding, Cattle and Small Stock, Livestock Production, physiology and management, Uncategorized, with global competitiveness

‹ Inheritance patterns of the Polled and Scur genes in South African beef cattle breeds

› Genotype imputation for genomic selection

DEADLINES for RESEARCHERS 2021

Proposals for 2021: TBC
Progress reports: 28 Jan 21
Final reports: 29 Jan 21 Final includes comprehensive report and popular article

COMMITEE MEETINGS for 2021

RMRDSA CSS Planning - TBC
Project Committee - TBC
Pork Planning - TBC

Calendar

< Apr 2021 >

Sun	Mon	Tue	Wed	Tur	Fri	Sat

				1	2	3
4	5	6	7	8	9	10
11	12	13	14	15	16	17
18	19	20	21	22	23	24
25	26	27	28	29	30	

PORK Priority Areas

Cattle & Small Stock Programmes

1 Sustainable natural resource utilisation

2 Improvement of Livestock production and forage

3 Management of agricultural risk to create a resilient Red Meat sector

4 Sustainable health and welfare for the Red Meat sector

5 Enhancement of production and processing of Animal Products

6 Consumer and market development of the Red Meat sector

7 Commercialisation of the emerging sector

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