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THE EFFECTS OF DIETARY STARCH/NEUTRAL DETERGENT FIBER RATIOS ON RUMINAL FERMENTATION AND INTRAMUSCULAR FAT DEPOSITION OF FATTENING YAKS

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I. INTRODUCTION

Yak, a unique herbivorous livestock species on the Qinghai-Tibet Plateau, has strong adaptability to the harsh plateau environment. However, due to the nutrition deficiency under traditional grazing feeding pattern, long raising cycle (6-7 years old and beyond) and poor meat quality (especially low intramuscular fat content) become the crucial confronting problems of yak industry. Carbohydrate is a key nutrient in ruminant ration, influencing energy metabolism as well as fat deposition. Grazing yaks usually consume natural grass containing substantial structural carbohydrates like Neutral Detergent Fiber (NDF). While, for the purpose of meeting nutritional requirement, concentrate feeds rich in non-structural carbohydrates such as starch are necessary to be included in a yak ration. Whether yaks can adapt to high-starch diets and the lipid metabolic response to different starch to NDF (SN) ratio are of importance to precise diet formulation for yaks. Therefore, this study investigated the effects of different dietary SN ratios on the ruminal fermentation and intramuscular fat (IMF) deposition of fattening yaks.

II. MATERIALS AND METHODS

The Institutional Animal Care and Use Committee of the Sichuan Academy of Grassland Sciences approved all procedures in this study. Yaks (n=51, 3-4 years old) with similar body weight were assigned randomly to 1 of 3 treatments. Yaks in different treatment group received (1) diet of low SN ratio (LSN, starch/NDF=0.41), (2) diet of medium SN ratio (MSN, starch/NDF=0.51), or (3) diet of high SN ratio (HSN, starch/NDF=0.64) with similar crude protein content and gross energy, respectively. There were 17 yaks for each treatment. The experimental diets fed as total mixed ration (TMR) consisted of concentrate, corn silage, wheat straw and corn straw.
After adaptation period of 7 d and experimental period of 115 d, blood samples were harvested for all yaks. Four yaks in each treatment were randomly selected for slaughtering measurements following standard procedure. Rumen fluid, serum, liver and *Longissimus dorsi* samples were collected to analyse ruminal fermentation parameters, serum biochemistry, genes expression and metabolites related to hepatic gluconeogenesis, intramuscular glycolysis and lipid metabolism, and IMF cell morphology. Statistical analyses were performed using the one-way ANOVA procedure of the SAS (SAS Institute Inc.).

III. RESULTS AND DISCUSSION

***Ruminal fermentation parameters and serum biochemistry*.** The results showed that the HSN diet significantly increased ruminal propionate, butyrate and microbial protein concentrations ($P<0.05$), while reducing acetate and acetate:propionate ratio ($P<0.05$). In terms of serum biochemistry, yaks fed the HSN and MSN diets had significant increases in serum glucose, triglycerides and apolipoprotein B100 levels ($P<0.05$).
Hepatic gluconeogenesis. The expression of hepatic gluconeogenic genes Fructose-1,6-bisphosphatase (FBPase) and Glucose-6-phosphatase (G6Pase) in the liver were significantly increased in HSN group ($P<0.05$, Figure 1), and the hepatic glycogen content increased significantly with the higher dietary SN ratio ($P<0.05$).
Intramuscular glycolysis. In *Longissimus dorsi,* the HSN and MSN diets significantly up-regulated the expression of glucose transporters GLUT1/4 and glycolysis-related genes Hexokinase 1/2 (HK1/2), Phosphofructokinase (PFK), Pyruvate Kinase (PK), and Pyruvate Dehydrogenase (PDH) ($P<0.05$). The contents of intermediate metabolites pyruvate and acetyl-CoA involved in intramuscular glycolysis were significantly enhanced by HSN diet ($P<0.05$). Meanwhile, Glyceraldehyde 3-phosphate (G3P) and glycerol concentrations of HSN and MSN yaks were significantly higher than those of LSN ($P<0.05$).
Intramuscular lipid metabolism. The yaks fed with HSN and MSN diets had significantly up-regulated genes expression of transcriptional regulation factors CCAAT-enhancer-binding protein α (C/EBPα), Peroxisome Proliferator-activated Receptor γ (PPARγ) and Sterol Regulatory Element-binding Protein 1 (SREBP1) when compared to those fed with LSN ($P<0.05$, Figure 2). The genes expression of key enzymes in *de novo* lipogenesis Acetyl-CoA Carboxylase (ACC), Fatty Acid Synthase (FAS) and Diacylglycerol Acyltransferase 1 (DGAT1) in the

muscle of HSN yaks were significantly higher than LSN ones (P<0.05). Moreover, the Lipoprotein Lipase (LPL) gene expression increased significantly with higher dietary SN ratio (P<0.05), and the HSN diet significantly enhanced the expression of lipolytic enzyme Carnitine Palmitoyl Transferase 1 (CPT1) in comparison with LSN diet (P<0.05).

IMF content and cell morphology. The diets with higher SN ratios increased IMF content of fattening yaks significantly from 1.05% to 2.28% and average area of IMF cell (P<0.05).

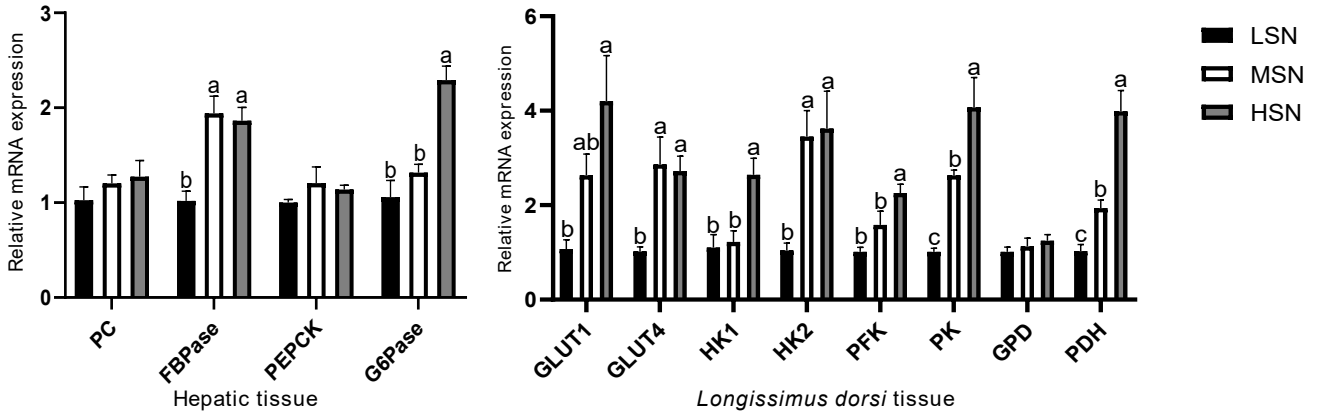


Figure 1. Effects of different dietary SN ratios on the expression of key genes related to hepatic gluconeogenesis and intramuscular glycolysis in fattening yaks

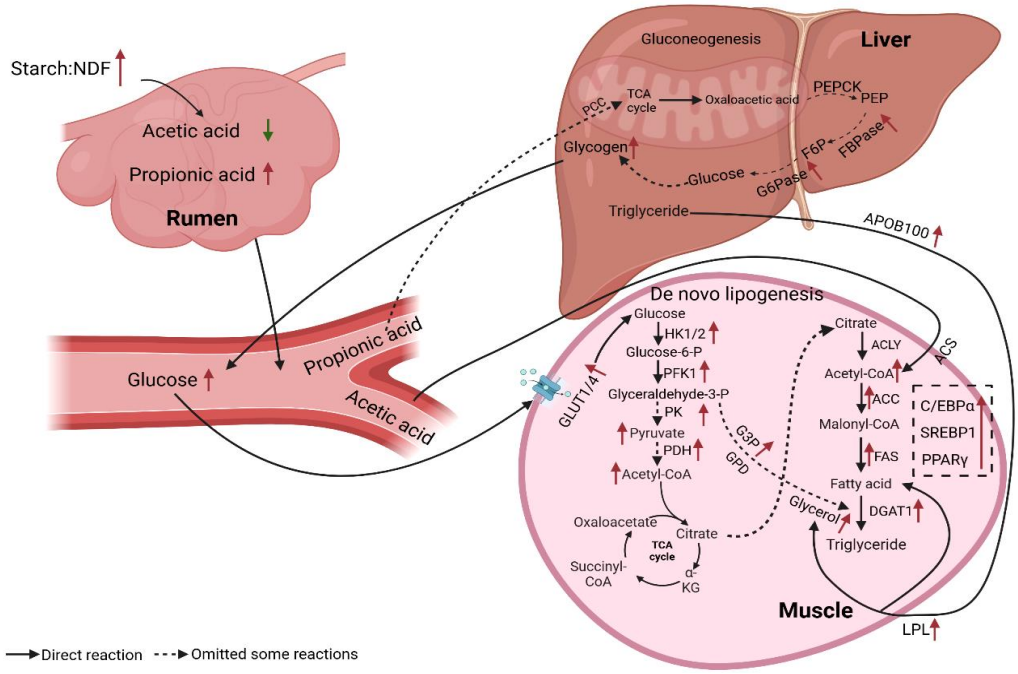


Figure 2. Effects of different dietary SN ratios on the IMF Deposition in fattening yaks

"↑" indicates a significant increase with dietary SN ratio, "↓" indicates a significant decrease with dietary SN ratio.

IV. CONCLUSION

The findings of this study indicate that fattening yaks have good adaptability to HSN (0.64) diet. High SN ratio diet is beneficial to increasing ruminal propionic acid fermentation which further improves hepatic gluconeogenesis and intramuscular glycolysis. More acetyl-CoA and glycerol derived from glycolysis were produced as the substrates for intramuscular *de novo* lipogenesis. Along with up-regulated genes expression of transcriptional regulation factors and key enzymes involved in lipogenesis, the IMF deposition of yak can be promoted as a consequence.

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