

Summary of Doctoral Thesis

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UGAS Specialty: Cryo-biosystem Science

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Title	Study on factors affecting feed intake of dairy cows immediately after calving
<p>While annual milk yield of dairy cows has been increasing, the production life of dairy cows has been gradually decreasing. Shortening of production life leads to a decrease in earnings in dairy management. After calving, milk production increases rapidly but feed intake increases modestly, causing most cows to be malnourished. If the cows cannot meet their nutrients requirement after calving, they are prone to develop metabolic diseases such as hypocalcemia and ketosis and to reduce reproductive performance. These metabolic and reproductive disorders are main causes for culling of dairy cattle. Therefore, meeting the nutrients requirements by increasing feed intake immediately after calving is an important issue to improve the productivity and longevity of dairy cows. The overall goal of this study was to find influential factors for feed intake in dairy cows immediately after calving. In order to achieve the goal, three experiments were carried out at Obihiro University of Agriculture and Veterinary Medicine. The first experiment was done to investigate the effect of parity number on the dry matter intake (DMI) of cows immediately after calving. The second experiment was done to investigate the influence of calving difficulty on DMI in dairy cows immediately after calving. The third experiment was done to investigate the effects the oxidative status on the DMI of dairy cows immediately after calving.</p> <p>[Experiment 1] I investigated the effect of parity number on the factors affecting the DMI of cows immediately after calving. Eighty-three cows were evaluated from 14 days before to 7 days after calving. The DMI and milk yield were measured for 7 days after calving, and the calving score was measured. Blood samples were collected throughout the experiment. The average DMI during the first week after calving was reduced in first-lactation heifers and high parity number cows. A quadratic relationship between the parity number and DMI was observed. The first lactation heifers had lower precalving serum total protein (TP) concentrations and milk yield, higher precalving serum nonesterified fatty acid (NEFA) concentrations and calving scores than the multiparous cows. The recovery rate of serum calcium (Ca) after calving was slow in the cows with parity 6. The DMI was positively affected by the serum Ca concentration after calving: milk yield and precalving serum TP concentration and was negatively affected by the calving score and precalving serum NEFA concentration. It is concluded that the DMI immediately after calving tends to be lower in first lactation heifers and high parity number cows, but factors that reduce the DMI differ according to parity number.</p> <p>[Experiment 2] I investigated the influence of calving difficulty on DMI in dairy cows immediately after calving using fifteen pregnant Holstein heifers and fifteen multiparous Holstein cows. DMI was measured 6 days after calving. Calving difficulty was evaluated with a calving score, and urinary cortisol concentration was measured. The calving score was higher in the first lactation heifers than in the multiparous cows. The average DMI 6 days after calving was lower in the first lactation heifers than in the multiparous cows. The urinary cortisol concentration at 4</p>	

days after calving were higher in the first lactation heifers than in the multiparous cows and were positively associated with the calving score. The average DMI was negatively associated with the calving score and the urinary cortisol concentration at 4 days after calving and was positively associated with the average milk yield 6 days after calving and the serum Ca concentrations at 3 days after calving. This experiment suggested that the low DMI immediately after calving in the first lactation heifers is mainly due to the stress derived from their first experiences for example calving, milking and tying to the stall, and to the lower energy requirement compared with that of the multiparous cows.

[Experiment 3] The objective of experiment 3 was to investigate the effects the oxidative status on DMI of dairy cows immediately after calving. Sixty-two Holstein cows were monitored from calving to 21 days after calving. DMI was measured from 1 to 6 days after calving. Body weight (BW) was measured once per week, and milk yield was measured twice per day after calving. Blood samples were taken at 0, 7, and 21 days after calving to determine reactive oxygen metabolites (ROM), biological antioxidant potential (BAP), and metabolic indicators. Oxidative stress index (OSI) was calculated by dividing ROM by BAP * 100. The average DMI 6 days after calving of the first lactation heifers and the cows in parity 2, 3, and 4 or more were 86.1, 124.1, 124.1, and 117.3 g/BW^{0.75}/d, respectively. Serum ROM concentrations tended to be lower in the first lactation heifers than multiparous cows and positively associated with average milk yield 6 days after calving. Serum BAP concentrations were lower in the first lactation heifers compared with multiparous cows through the experiment and were positively associated with average DMI and milk yield 6 days after calving. OSI was not affected by parity number of cows except for 21 days after calving, and did not differ due to the number of in days after calving. The DMI was not associated with OSI at 0 days after calving, but it was negatively associated with OSI at 7 days after calving. These results indicate that although the production of peroxides rose with the increase in milk production, the DMI and the antioxidant capacity also increased, so that the increase of milk production did not affect oxidative stress in this study. Therefore, the difference in the average DMI 6 days after calving among the parity observed in this study might not be due to oxidative stress. It is concluded that the oxidative stress has little effect on DMI immediately after calving, but the low DMI would increase the oxidative stress of the cows after calving. Rapid increase in DMI immediately after calving together with an increase in milk yield must be an important issue for the prevention of the performance deterioration due to oxidative stress in cows after calving.

These experiments demonstrate that the DMI intake immediately after calving is affected by parity number of cows, and that the DMI is easy to be low in the first lactation heifers and cows with a high number of calving. In the case of the first lactation heifers, the DMI immediately after calving is likely to be suppressed by malnutrition in the late gestation period and stress around calving. On the other hand, delayed recovery of serum Ca concentration after calving is a limiting factor for the DMI in high parity cows. Since the influential factors affecting the DMI differ between the first lactation heifers and high parity cows, feeding management around calving according to the number of parity is required to enhance the DMI immediately after calving. Moreover, these experiments show that oxidative stress is unlikely to increase even with increased milk production, because the increase in milk yield increases the peroxides production and also increases the antioxidant capacity by increasing feed intake. This implies that the DMI of dairy cows immediately after calving is less susceptible to oxidative stress, and it suggests that increasing the feed intake immediately after calving can reduce the oxidative stress

and the risk of metabolic and reproductive disorders due to oxidative stress. These results would contribute to the expand of longevity of dairy cows through reducing the risk of metabolic and reproductive disorders by improving feed intake immediately after calving.

博士論文要約 (Summary)

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タイトル	分娩直後における乳牛の飼料摂取量に影響を及ぼす要因に関する研究
<p>乳牛の個体乳量は年々増加する一方で、徐々に乳牛の生産寿命は減少している。乳牛の生産寿命の短縮は、酪農経営における収益の減少につながる。分娩後、乳量は速やかに増加するが、飼料摂取量の増加は緩やかであり、ほとんどの乳牛が栄養不足に陥いる。分娩後、栄養要求量を満たすことができないと、代謝病や繁殖成績の低下を招きやすくなる。代謝病や繁殖障害は乳牛を淘汰する主な原因である。このため分娩後の飼料摂取量を増やして栄養要求量を満たすことは乳牛の生産寿命の増加にとって重要な課題である。この研究の目的は、乳牛の分娩直後における飼料摂取量に影響を及ぼす要因を明らかにすることであり、3つの試験を実施した。試験1では乳牛の産次が分娩直後の飼料摂取量に及ぼす影響について検討した。試験2では分娩前後のストレスが分娩直後の飼料摂取量に及ぼす影響について検討し、試験3では酸化ストレスが分娩直後の飼料摂取量に及ぼす影響について検討した。</p> <p>【試験1】ホルスタイン種乳牛83頭を分娩前14日から分娩後7日目まで試験に用い、分娩後の飼料摂取量、乳量、血液成分、体重、分娩スコアを測定した。分娩後7日間の平均乾物摂取量は初産牛と産次数の多い牛で低くなり、摂取量と産次との間には二次曲線的関係が認められた。経産牛に比べ初産牛は分娩前の血清中のタンパク質濃度と乳量が低く、分娩前の血清遊離脂肪酸濃度と分娩スコアが高かった。6産の牛は、分娩後の血清カルシウム濃度の回復が遅かった。分娩後の乾物摂取量は、血清カルシウム濃度、乳量、分娩前の血清タンパク質濃度と正の相関が、分娩スコア、分娩前の遊離脂肪酸濃度と負の相関が認められた。これらのことから分娩直後の乾物摂取量は初産牛と産次数の多い牛で少なくなるが、その低下の要因は、初産牛と産次数の多い牛では異なることが明らかになった。</p> <p>【試験2】ホルスタイン種乳牛30頭を用いて分娩難易度が分娩後6日間の乾物摂取量におよぼす影響を検討した。分娩難易度は分娩スコアで評価し、ストレスの指標として尿中コルチゾール濃度を測定した。分娩スコアは経産牛よりも初産牛で高く、分娩後6日間の平均乾物摂取量は経産牛に比べ初産牛で少なかった。分娩後4日目の尿中コルチゾール濃度は経産牛よりも初産牛で高く、分娩スコアとの間に負の相関が認められた。分娩後の乾物摂取量は分娩スコアおよび分娩後4日目の尿中コルチゾール濃度との間に負の関係が、分娩後3日目の血清カルシウム濃度および乳量との間に正の関係が認められた。これらのことから初産牛の分娩直後の乾物摂取量の少なさ、主に分娩や搾乳などの初体験によるストレスの受けやすさと経</p>	

産牛に比べ少ないエネルギー要求量に由来すると判断された。

【試験 3】ホルスタイン種乳牛 62 頭を用いて酸化ストレスが分娩直後の乾物摂取量に及ぼす影響を検討した。分娩後 6 日間の乾物摂取量を測定するとともに、体重および乳量を測定した。また、分娩後 0、7、21 日目に採血し、代謝物質を測定するとともに、過酸化物質(ROM)および抗酸化力(BAP)を測定して酸化ストレス度(OSI)を算出した。血清中 ROM 濃度は初産牛で低くなる傾向があり、分娩後 6 日間の平均乳量との間に正の相関が認められた。血清中の BAP 濃度は経産牛に比べ初産牛で低い値を示し、分娩後 6 日間の平均乾物摂取量や平均乳量との間に正の相関が認められた。OSI は分娩後 21 日目以外では、乳牛の産次数の影響を受けず、分娩後日数の違いによる差もみられなかった。分娩日の OSI と分娩後 6 日間の乾物摂取量の平均値との間には有意な相関は認められなかったが、分娩後 7 日目の OSI と分娩後 6 日間の乾物摂取量の平均値との間には負の相関が認められた。これらの結果から、乳量の増加とともに過酸化物質の生成は増加したが、同時に DMI および抗酸化能力も増加したため、乳量が増加しても酸化ストレスは高まらなかったと推察された。このため産次の違いによる乾物摂取量の差は、酸化ストレス以外の要因によってもたらされたと判断された。また、酸化ストレスが分娩直後の乾物摂取量に及ぼす影響は小さいが、分娩後の乾物摂取量が減少すると抗酸化物質の摂取量が減少し、酸化ストレスが高まると推察された。

これらの研究の結果、分娩直後の乾物摂取量は初産牛と産次数の多い牛で少なくなり、初産牛では分娩前の低栄養や難産によって、産次数の多い牛では分娩後の血清カルシウム濃度の回復の遅延によって採食量が抑制されやすいことが示された。さらに乳量の増加とともに過酸化物質の生成は増加するが、同時に DMI および抗酸化能力も増加する。このため酸化ストレスが分娩直後の乾物摂取量に及ぼす影響は小さいが、分娩後の乾物摂取量が減少すると抗酸化物質の摂取量が減少し、酸化ストレスが高まることが示唆された。