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# 主　論　文　の　要　旨

論文題目　Developing Smallholder Dairy Buffalo Farm Productivity Through Improvement of Nutrition,Body Condition, and Milk Production in South Luzon, Philippines
（フィリピン・南ルソンにおける栄養成分、ボディーコンディション、泌乳量の改善を通じた小規模水牛酪農の発展）

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# 論　文　内　容　の　要　旨

The Philippine annual per capita milk consumption was 22 kg in 2017, and the national dairy consumption reached 2,486 MMT (LME); however, domestic milk production was only at 22.76 MMT (LME). This demand presents massive potential for local dairy sector development by engaging smallholder farming families in small-scale milk production. The majority of this marginalized farming sector, with an average daily family income of less than US$ 7, lives in rural areas and commonly owns livestock such as carabaos (*Bubalus bubalis*), mainly used for draught purposes and have the low genetic potential for milk production but can be upgraded using dairy buffalo germplasm. A crossbred buffalo provides premium milk averaging 5 kilograms daily for 10 months. Genetic development of dairy buffaloes is a tedious and lengthy process, and alongside this effort, it is critical to determine other multitudes of factors influencing farm and milk productivity. Understanding these critical determinants will help the government design better programs for dairy buffalo farmers.

Chapter 2 is the first local study to apply the Bayesian approach and analyzed the factors influencing the milk productivity of smallholder dairy buffalo farmers. Cross-sectional data using household interview questionnaires of 58 dairy buffalo farmers was used. The empirical results revealed that among the socio-economic, farm, and technology characteristics investigated, the household size has a positive effect, the number of lactating dairy buffaloes, a negative effect, and the technology adoption of data recording a positive effect on milk productivity of dairy buffalo farmers rendering these factors critical in the analysis of milk productivity. To address these critical factors, it is recommended to regularly conduct training for smallholder farmers on dairy buffalo production and enterprise development, conduct further studies on the effects of technology adoption, the development, and use of a dairy handbook or manual to serve as a guide and reference for better productivity.

One of the vital technologies transferred to farmers is dairy buffalo nutrition and feeding management to stimulate better and sustain the local dairy industry. A lactating cow requires a diet that supplies the nutrients to meet the demand of milk production. A widely recommended technique employed as a feeding guide and evaluating tool for nutritional management is the body condition scoring system. The third chapter is a retrospective study of body condition scores, milk yield, and lactation stage records of 34 purebred and crossbred dairy Murrah buffaloes, and the climatic condition were used to determine their relationships to each other. The visual assessments developed for Murrah buffalo were used in BCS determination by a trained researcher. Significant correlations ($P<0.01$) between all parameters except for rainfall were found. BCS was negatively correlated ($r = -0.2305$) to milk yield and affected milk yield by 0.8583 kg/day per unit change in BCS. Milk yield was affected by early lactation positively ($r = 0.3962$) while BCS negatively ($r = -0.2627$). In the early lactation stage, the estimated rate (b=slope) of the increase and decrease for milk yield was 1.5194 kg/day and 0.2667 units in BCS, respectively. The relationship of the breed to BCS and milk yield were significant. The milk yield was positively affected in purebred ($r= 0.1160$) and negatively in BCS ($r= -0.1444$). The purebred produced significantly ($P<0.01$) more milk (5.44 kg/day) than crossbred (4.98 kg/day) in the overall period. The highest milk yield was observed both in March for purebred (6.40 kg/day) and crossbred (5.99 kg/day) while the lowest in August (4.82) and October (4.23) for purebred and crossbred, respectively. BCS and milk yield were positively correlated ($P<0.01$) with temperature while negatively for relative humidity. In conclusion, BCS, stage of lactation, breed, temperature, and relative humidity affect milk production. A practical recommendation would be to look at BCS during specific periods such as breeding, calving, 60- and 90-days post-calving, and drying-off. The information obtained would benefit the dairy buffalo farmers to improve animal management and milk productivity.

Synonymous to excellent animal nutrition is forage quality. Forages constitute a significant source of nutrients needed for milk production, and good quality forage is of utmost importance because this affects the quantity and quality of milk that the dairy animals will produce. Chapter 4 evaluated the performance of Sweet Sorghum and Mombasa forage grasses fertilized with urea and raw buffalo manure by comparing dry matter yield per hectare, nutrient composition (crude protein, crude fiber, neutral detergent fiber, and acid detergent fiber), and rumen digestibility using in sacco degradation. Sweet Sorghum attained higher ($P < 0.05$) dry matter yield per hectare in the main and first ratoon crop. Forage crops fertilized with urea alone and a combination of urea and buffalo manure attained the highest ($P < 0.05$) dry matter yield in the first and second ratoon crop. Nutrient composition (crude protein and crude fiber), including detergent fibers of Mombasa and Sweet Sorghum with fertilizer treatments, were affected ($P< 0.05$) by fertilizer applications in the main and ratoon crops. However, acid detergent fiber was unaffected ($P < 0.05$) in all harvest periods. There were no significant differences in the means of dry matter (%) digestibility, crude protein (%) digestibility, neutral detergent (%) digestibility, and effective digestibility ($P < 0.05$) observed between Mombasa and Sweet Sorghum. Mombasa is a highly recommended forage crop because it is cheaper to establish and very stable with minimal management. Sweet Sorghum can be used as a substitute for feeding when Mombasa is not available. Recommendations for further studies include evaluation of other high-value forage grasses and fertilizer sources and rates to find more efficient forage crops for animal production.

To further investigate Sweet Sorghum and Mombasa, the final chapter compared the effects of feeding Sweet Sorghum and Mombasa to lactating buffalo milk yield, composition, and property. A total of 20 lactating dairy buffaloes were kept in individual research pens and grouped into three. Each group was fed separately with Treatment 1 (Sweet Sorghum), Treatment 2 (Mombasa), and Control (Napier) 45 days. Milk was collected individually, twice a day in the morning and afternoon. Milk samples were analyzed for fat, lactose, protein, milk solids-not-fat, total solids, and freezing point. The time of milk collection significantly affected dairy buffalo milk fat. Milk collected in the morning contained less fat ($p\text{-value} < 0.0001$) than milk collected in the afternoon. Morning milk from Mombasa-fed buffaloes has a higher fat content. Morning milk has significantly ($p\text{-value} = 0.0007$) higher protein compared to afternoon collection. There is a larger ($p\text{-value} = 0.0005$) percentage of SNF in morning milk compared to afternoon collection. Morning milk contained less ($p\text{-value} < 0.0001$) total solids than collected milk in the afternoon. There is no evidence to support that the treatments or time of collection significantly affected lactose. The freezing point of dairy buffalo milk collected in the morning is lower than afternoon milk. It is highly recommended for dairy buffalo farmers to perform twice a day milk collection to maximize the premium quality of buffalo milk. Prospects would be to investigate forages and legumes for a more extended feeding trial to observe the evident effect on milk production and composition.