Effects of Mount Agung eruption on botanical composition and nutritive value of ration fed and rumen performance of Bali cattle in evacuation zones

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Abstract. Mount Agung eruption, August to December 2017, that is located in Karangasem Regency, Bali Province, caused Bali cattle to be evacuated. This study was undertaken to compare botanical composition and nutritive value of forage fed to Bali cattle and rumen performance before and after eruption in evacuation zones i.e. Sidemen and Nongan Villages. The first phase was a survey conducted in December 2017 on farmers to collect information on botanical composition fed before and after the eruption. The second phase was laboratory forage sample analysis from January to May 2018 for their nutritive value and rumen performance i.e. pH, NH₃ and total VFA, Digestible Organic Matter in Rumen (DOMR) and microbial protein synthesis (MPS). Data was analysed using Anova. Results showed that there was more composition of forage fed before eruption in both evacuation zones compared to those of after the eruption. In Nongan evacuation zone, DOMR was higher 4161.81b ± 188.18 g/head/day vs. 3318.36a2) ± 236.89 g/head/day but lower in Sidemen evacuation zones 4403.53a2) ± 143.81 g/head/day vs. 4818.17a ± 279.77 g/head/day. In summary, there was more botanical composition of forage fed to Bali cattle.

1. Introduction.
Bali cattle as one of the Indonesian beef cattle that plays important role in national meat supply. Not only have to pay attention on genetic potential of Bali cattle, but also have to pay attention on their nutrient intake to be able to improve their breeding stock. The improvement of Bali cattle have strategy goals such as to conserve and to improve the Bali germplasm. Furthermore, [1] urged that its impact-oriented benefits could directly sustain pro-poor initiatives to reduce poverty and hunger that are consistent with income growth, socioeconomic benefits, improved livelihoods and self-reliance.

The availability of forage through years plays important role in ruminant farming system. Forage provided to livestock consisted of native grass and legume that took over 40% to 80% from the total DM feed or about 1.5 to 3% from bodyweight of livestock. Forage is source of crude fiber, mineral and protein that supply the nutrient requirement of livestock [2]. The eruption of Mount Agung affected the availability of forage due to its ash contaminated the forage thus the growth of forage in Sidemen and Nongan conservation zones. As a result, the availability and the quality of forage provided to their livestock around the Mount Agung zone decreased. Furthermore, villagers and their
livestock who lived around the Mount Agung zone had to evacuate to Sidemen and Nongan villages that were about 20 to 23 km from the Mount Agung zone. Therefore, smallholder farmers had to cut and carry forage around the both villages to provide to their livestock as well as donated concentrate by donators. As the villagers and their livestock stayed over three months in both evacuation zones, the availability of forage became crucial problem whether to keep or to sell their livestock with low prices. There more livestock were sold with low prices during the evacuation period in both zones that influenced the number of Bali cattle thus influenced the meat supply from Karangasem Regency. Karangasem Regency has the highest number of Bali cattle and was officially promulgated a designation regency for improvement of goat farming by the Indonesian Minister of Agriculture [3].

One of important limiting factors for animal performance is the daily amount of absorbable amino acids (AA) in their small intestine [4]. The amino acids reaching small intestine are supplied by microbial protein, the un-degraded feed protein, amino acids and peptides from feed which escape degradation, and endogenous secretions. The microbes that are produced in the rumen, and then pass down the digestive tract, may supply 60 to 80 per cent of the amino acids absorbed from the small intestine. The efficiency of microbial protein synthesis is a major factor affecting the overall amino acid requirement of ruminants [5]. Adequate dietary fiber is very important to maintain rumen health and microbial protein synthesis (MPS) by sustaining a stable environment in the rumen [6].

Based on these current phenomena, this study was undertaken to compare botanical composition and nutritive value of forage fed to Bali cattle and their rumen performance i.e. pH, NH₃ and VFA production, microbes protein synthesis before and after the Mount Agung eruption in evacuation zones i.e. Sidemen and Nongan Villages.

Based on these current phenomena, this study was undertaken to compare botanical composition and nutritive value of forage fed to Bali cattle and their rumen performance i.e. pH, NH₃ and VFA production, microbes protein synthesis before and after the Mount Agung eruption in evacuation zones i.e. Sidemen and Nongan Villages.

2. Materials and Methods.
Data collection was taken in two phases. The first phase was a survey conducted in December 2017 on farmers to collect information on botanical composition and nutritive value of forage fed before and after the eruption of Mount Agung in the Sidemen and Nongan evacuation zones. Nongan Village, Rendang District, Karangasem Regency and Talibeng Village, in Sidemen District in Karangasem Regency were about 20 and 23 km from Mount Agung zone. The second phase was laboratory forage sample analysis from January to May 2018 for their nutritive value as well as rumen performance of Bali cattle i.e. pH, NH₃ and total VFA of rumen fluids, Digestible Organic Matter in Rumen (DOMR) and microbial protein synthesis (MPS). Nutritive value of forages were analysed using Official Method of Analysis [7] and in vitro digestibility was analysed using modified In Vitro Technique by [8] NH₃ was analysed by Spectrophotometer according to [9], VFA was analysed by Gas Chromatography (GC) by [7] and MPS was analysed by [10]. Data was analysed by using descriptive statistics and Anova using multivariate using SPSS version 24.

3. Results and Discussion

3.1 Nongan evacuation zone

3.1.1 Botanical composition and their nutritive value. Twenty five smallholder farmers were surveyed who had flock size ranging between 2-14 Bali cattle of different physiological state. There were total of 163 Bali cattle consisted of 48 mature males, 67 mature females and 48 calves. Observation focused on mature males and females Bali cattle. Botanical composition and their nutritive values provided by smallholder farmers in Nongan evacuation zone before and after the Mount Agung eruption were presented in Table 1.

Botanical composition of forage provided by smallholder farmers before Mount Agung
eruption was more varied with no concentrate supplementation. However, when smallholder farmers and their livestock were evacuated in Nongan Village, they provided less varied of botanical composition to their livestock with 1 kg of concentrate supplementation per head per day. This was due to the farmers found more difficult to cut and carry the forage as the availability and quality of forage decreased after Mount Agung eruption particularly after 3 months of the eruption. This resulted in lower crude protein.

Table 1. Botanical composition and nutritive values of feed provided in Nongan evacuation zone

| Botanical Composition | Given (kg) | Dry Matter (%) | Crude Protein (%) | Crude Fiber (%) | Ether Extract (%) | Organic Matter (%) | Gross Energy (kcal/kg) |
|-----------------------|-----------|----------------|-------------------|----------------|------------------|-------------------|-----------------------|
| Elephant grass        | 25.00     | 61.21          | 6.34              | 18.85          | 4.17             | 50.63             | 2166.94               |
| Caliandra             | 3.00      | 17.90          | 5.65              | 4.80           | 2.63             | 16.68             | 776.74                |
| Gliricidia sepium     | 2.00      | 9.76           | 2.51              | 1.30           | 0.39             | 8.94              | 463.68                |
| Jackfruit leaves      | 3.00      | 9.37           | 1.17              | 1.87           | 0.41             | 7.03              | 337.36                |
| Cassava               | 0.30      | 1.76           | 0.06              | 0.09           | 0.01             | 1.70              | 87.85                 |
| **Total**             | 33.30     | 100.00         | 15.73             | 26.91          | 7.62             | 84.97             | 3832.57               |

| Botanical Composition | Given (kg) | Dry Matter (%) | Crude Protein (%) | Crude Fiber (%) | Ether Extract (%) | Organic Matter (%) | Gross Energy (kcal/kg) |
|-----------------------|-----------|----------------|-------------------|----------------|------------------|-------------------|-----------------------|
| Elephant grass        | 20.00     | 37.31          | 3.86              | 11.49          | 2.54             | 30.86             | 1320.93               |
| Calliandra            | 5.00      | 22.73          | 7.18              | 6.10           | 3.33             | 21.18             | 986.43                |
| Concentrate           | 1.00      | 14.07          | 2.30              | 1.53           | 1.21             | 13.99             | 591.36                |
| Sugar cane shoot      | 2.00      | 25.89          | 0.97              | 0.57           | 1.52             | 23.37             | 991.47                |
| **Total**             | 28.00     | 100.00         | 14.32             | 19.68          | 8.60             | 89.40             | 3890.19               |

3.1.2 Nutrient intake. Nutrient intake of Bali cattle before and after Mount Agung eruption was shown in Table 2. Intake of DM, CP, CF, EE, OM and GE of forage were significantly higher (P<0.05) when the cattle were in Nongan eruption zone after the Mount Agung eruption. This higher intake was due to the cattle provided with concentrate 1 kg per head per day. Concenrate had lower CF and higher digestibility compared to forage. This resulted in higher nutrient consumption.

3.1.3 Rumen fermentation in vitro. Rumen fermentation in vitro before and after Mount Agung eruption showed pH of rumen fluid of both rations was in normal range. The differences of forage composition of ration caused pH in vitro was not significant (P>0.05). Rumen pH was one of factors that supported the growth of population and activity of rumen microbes. Optimal rumen pH for the optimal growth of population and activity of rumen microbes was 6.0 – 6.9 [11] and normal pH of rumen fluid was 6 – 7 [12].

Total VFA concentration rumen fermentation in vitro was also not statistically different (P>0.05). VFA was the products of carbohydrate fermentation as energy resources. Although energy consumption of Bali cattle was significantly higher (P<0.05) after the Mount Agung eruption, their VFA productions were not significantly different (P>0.05) before and after the eruption. However, NH₃ production was significantly higher i.e. 7.1156 mMol (P<0.05) after the Mount Agung eruption compared to 4.0698 mMol before the eruption. NH₃ was the product of the degradation of crude protein by microbial rumen. Protein content of feed after the eruption was lower although their consumption was higher i.e. 49.30%. The higher protein consumption resulted in higher NH₃ production. NH₃ concentration resulted in rumen fermentation in vitro of the ration that consisted of 70% forage and 30% concentrate ranged between 8.78 – 10.71 mMol [13]. An ideal N-NH₃ concentration that supported the growth of bacteria optimally was 6-21 mMol [14].
Table 2. Nutrient intake, rumen fermentation and microbial protein synthesis in vitro in Nongan evacuation zone

|                     | Before Mount Agung eruption | After Mount Agung eruption |
|---------------------|-----------------------------|---------------------------|
| (a) Nutrient Intake :|                             |                           |
| Dry Matter, kg      | 5.12                        | 6.72                      |
| Crude Protein, g/d  | 805.67                      | 1202.85                   |
| Crude Fiber, g/d    | 1378.52                     | 1655.90                   |
| Ether Extract, g/d  | 390.07                      | 509.60                    |
| Organic Matter, kg/d| 4.35                        | 5.67                      |
| Gross Energy, kcal/d| 19630.82                    | 26150.28                  |
| (b) Rumen fermentation in vitro : |                   |                           |
| pH                  | 6.8790                      | 6.9760                    |
| Total VFA, mMol     | 62.9640                     | 62.5400                   |
| N-NH₃, mMol         | 4.0698ᵃ                    | 7.1156ᵇ                   |
| (c) Microbial protein synthesis in vitro : |       |                           |
| DOMR g              | 3318.36ᵃᵇ ± 236.88608      | 4161.81ᵇ ± 188.17950     |
| Microbial N, g      | 106.19ᵃ ± 7.58035           | 133.18ᵇ ± 6.02174        |
| MPS, g              | 663.67ᵃ ± 47.37722         | 832.36ᵇ ± 37.63590       |
| Purine Absorption, mMol | 146.06ᵃ ± 10.42690      | 183.19ᵇ ± 8.28300        |

Means in a column with different superscripts differed significantly at the .05 level.

3.1.4 Microbial protein synthesis in vitro. Digestible organic matter in the rumen (DOMR) was significantly higher (P<0.05) in ration of Bali cattle when they were in Nongan evacuation zone after the eruption (Table 2). The higher crude protein consumption resulted in higher NH₃ production. Microbial rumen required sufficient NH₃. The more production of NH₃ of the ration after the Mount Agung eruption was beneficial to the growth of rumen microbial and this was shown by the higher SPM i.e. 832.36ᵇ ± 37.63590 g compared to those of before the eruption i.e. 663.67ᵃ ± 47.37722g. DOMR and MPS of ration of Bali cattle in Nongan evacuation zone was significantly higher compared to DOMR and MPS before the eruption being 1843.08 g and 368.62 g [13].

3.2 Sidemen evacuation zone

3.2.1 Botanical composition and their nutritive value. Similarly to Nongan evacuation zone, king grass always dominated the composition of forage before and after the Mount Agung eruption (Table 3). Rearing Bali cattle by smallholder farmers was side job and done traditionally where the flock size ranged between 2 to 14, therefore, feeding their livestock was mostly forage and feeding concentrate was rare and costly. However, concentrate was fed to Bali cattle in both evacuation zones where in Sidemen zone it was 0.5 kg concentrate per head per day (Table 3). Feeding concentrate to Bali cattle after the Mount Agung eruption both in evacuation zones was due to donated by donators who were aware about livestock in evacuation zones.

3.2.2 Nutrient intake. Before the Mount Agung eruption, more botanical composition fed to Bali cattle in Sidemen evacuation zone. Forage fed as protein sources such as Calliandra, Gliricidia sepium and Leucaena leucocephala. In contrast, concentrate was the source of protein, so their protein content of ration was almost twice less than of the ration fed before the eruption being 8.85% and 17.94%, respectively (Table 3), and was the protein consumption (Table 4).
Table 3. Botanical composition and nutritive values of feed provided in Sidemen evacuation zone

(a) Before Mount Agung Eruption in Sidemen Evacuation Zone

| Botanical Composition | Weight (kg) | Dry Matter (%) | Crude Protein (%) | Crude Fiber (%) | Ether Extract (%) | Organic Matter (%) | Gross Energy (kcal/kg) |
|-----------------------|-------------|----------------|-------------------|----------------|------------------|-------------------|------------------------|
| Elephant Grass        | 20.0        | 38.30          | 3.96              | 11.79          | 2.61             | 31.68             | 1355.74                |
| Calliandra            | 2.0         | 9.33           | 2.95              | 2.50           | 1.37             | 8.69              | 404.97                 |
| Gliricidia sepium     | 4.0         | 15.27          | 3.92              | 2.03           | 0.61             | 13.99             | 725.25                 |
| L. leucocephala       | 4.0         | 17.77          | 5.30              | 3.49           | 0.93             | 16.68             | 835.48                 |
| Native grass          | 5.0         | 19.33          | 1.80              | 6.11           | 1.24             | 18.62             | 705.56                 |
| **Total**             | **35.0**    | **100.00**     | **17.94**         | **25.92**      | **6.77**         | **89.67**         | **4027.00**            |

(b) After Mount Agung Eruption in Sidemen Evacuation Zone

| Botanical Composition | Weight (kg) | Dry Matter (%) | Crude Protein (%) | Crude Fiber (%) | Ether Extract (%) | Organic Matter (%) | Gross Energy (kcal/kg) |
|-----------------------|-------------|----------------|-------------------|----------------|------------------|-------------------|------------------------|
| Elephant Grass        | 25.0        | 47.40          | 4.91              | 14.60          | 3.23             | 39.21             | 1678.03                |
| Concentrate           | 0.5         | 7.15           | 1.17              | 0.78           | 0.61             | 7.11              | 300.49                 |
| Gliricidia sepium     | 2.0         | 26.31          | 0.99              | 0.57           | 1.54             | 24.10             | 1007.60                |
| Native grass          | 5.0         | 19.14          | 1.78              | 6.05           | 1.23             | 18.44             | 804.48                 |
| **Total**             | **32.50**   | **100.00**     | **8.85**          | **21.98**      | **6.62**         | **88.85**         | **3790.60**            |

3.2.3 Rumen fermentation in vitro. Nutrient consumption affected the rumen fermentation. The product of rumen fermentation in vitro showed that pH rumen fluid was in normal range (Table 4). Optimal pH for the growth of microbial rumen was 6 – 6.9 [15] and normal pH rumen fluid was 6 - 7 [12]. The concentration of total VFA and NH₃ was not significantly different (P>0.05) between before and after the Mount Agung eruption. Sufficient concentration of NH₃ and total VFA was required for optimal growth and activity of microbial rumen being 50 mgNH₃/l and 70 – 130 mMol [16]. The level of VFA concentration was affected by basal ration, type of carbohydrate of feed, the physical form of the feed, rate of consumption, feeding frequency and the usage of chemical additive [16].

Table 4. Nutrient intake, rumen fermentation and microbial protein synthesis in vitro in Sidemen evacuation zone

|                         | Before Mount Agung eruption | After Mount Agung eruption |
|-------------------------|-----------------------------|---------------------------|
| (a) Nutrient Intake :   |                             |                           |
| Dry Matter, kg          | 6.55                        | 6.61                      |
| Crude Protein, g/d      | 1174.77                     | 1082.96                   |
| Crude Fiber, g/d        | 1697.42                     | 1769.47                   |
| Ether Extract, g/d      | 443.12                      | 405.34                    |
| Organic matter, kg/d    | 5.87                        | 5.88                      |
| Gross Energy, kcal/d    | 26374.82                    | 25072.86                  |
| (b) Rumen fermentation in vitro : |                   |                           |
| pH                      | 6.9330                      | 6.8600                    |
| VFA, mMol               | 77.274                      | 66.1440                   |
| N-NH₃, mMol             | 6.5051                      | 5.5327                    |
| (c) Microbial Protein Synthesis in vitro : | |                           |
| DOMR, g                 | 4818.17⁺ ± 279.76791       | 4403.53⁽²⁾ ± 143.80926    |
| Microbial N, g          | 154.18⁺ ± 8.95257         | 140.91⁺ ± 4.60190        |
| MPS, g                  | 963.63⁺ ± 55.95358        | 880.71⁺ ± 28.76185       |
| Purine Absorption, mMol | 212.08⁺ ± 12.31441        | 193.83⁺ ± 6.32998        |

3.2.4 Microbial protein synthesis in vitro. Microbial protein synthesis was affected by the level of DOMR. Before the Mount Agung eruption, DOMR was 4818.17⁺ ± 279.76791 g and after the
eruption, the amount of DOMR was 4403.53 ± 143.80926 g. The higher level of the DOMR before the eruption resulted in the higher level of SPM before the Mount Agung eruption (Table 4). Microbial protein synthesis was varied between livestock, as it affected by feed fed to the livestock and even the same quality of feed, their responses were also varied. Feeding forage and concentrate affected microbial protein synthesis variously 70-279 g MCP/kg DOMR [15].

4. Conclusion.
Botanical composition of forage provided to Bali cattle by smallholder farmers before the Mount Agung eruption was more varied compared to after Mount Agung eruption both in Sidemen and Nongan evacuation zones. Bali cattle in Nongan evacuation zone after Mount Agung eruption consumed more nutrient, produced more VFA, NH$_3$ and SPM (P< 0.05). In contrast, Bali cattle were in Sidemen evacuation zone after Mount Agung eruption consumed less nutrient, produced less VFA, Total NH$_3$ and SPM (P<0.05).

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