Turnitin Originality Report

- Processed on: 23-Feb-2020 8:35 PM +08
- ID: 1262260528
- Word Count: 5448
- Submitted: 1

Turnitin No.15

Similarity Index

17%

Similarity by Source

Internet Sources:
N/A
Publications:
17%
Student Papers:
N/A

1% match (publications)
Roy, A., G.P. Mandal, and A.K. Patra. "Evaluating the performance, carcass traits and conjugated linoleic acid content in muscle and adipose tissues of Black Bengal goats fed soybean oil and sunflower oil", Animal Feed Science and Technology, 2013.
1% match (publications)
Abdelrahim Abubakr, Abdul Razak Alimon, Halimatun Yaakub, Norhani Abdullah, Michael Ivan. "Effect of Feeding Palm Oil By-Products Based Diets on Muscle Fatty Acid Composition in Goats", PLOS ONE, 2015
1% match (publications)
"Bioactive Molecules in Food", Springer Science and Business Media LLC, 2019
1% match (publications)
"Proceedings of the 10th International Symposium on the Nutrition of Herbivores", Advances in Animal Biosciences, 2018
1% match (publications)
Kazeem Dauda Adeyemi, Awis Qurni Sazili, Mahdi Ebrahimi, Anjas Asmara Samsudin et al. "Effects of blend of canola oil and palm oil on nutrient intake and digestibility, growth performance, rumen fermentation and fatty acids in goats", Animal Science Journal, 2016
1% match (publications)
"Should animal fats be back on the table? A critical review of the human health effects of animal fat", Animal Production Science, 2014.
1% match (publications)
Nguyen Trong Co. "Plant Location Evaluation from the Aspects of Financial and Non-financial Criteria", Asian Journal of Scientific Research, 2017
1% match (publications)
Timm-Heinrich, M.. "Oxidative stability of structured lipids containing C18:0, C18:1, C18:2, C18:3 or CLA in sn2-position - as bulk lipids and in milk drinks", Innovative Food Science and Emerging Technologies, 200406
< 1% match (publications)
Giuseppe Luciano, Antonio Natalello, Simona Mattioli, Mariano Pauselli et al. "Feeding lambs with silage mixtures of grass, sainfoin and red clover improves meat oxidative stability under high oxidative challenge", Meat Science, 2019
< 1% match (publications)
Pauline Beguin, Anne-Catherine Schneider, Eric Mignolet, Yves-Jacques Schneider, Yvan Larondelle. "Polyunsaturated fatty acid metabolism in enterocyte models: T84 cell line vs. Caco-2 cell line", In Vitro Cellular & Developmental Biology - Animal, 2013
< 1% match (publications)
Simarpreet Singh, MS Dasgupta. "Evaluation of research on CO 2 trans-critical work recovery expander using multi attribute decision making methods", Renewable and Sustainable Energy Reviews, 2016
< 1% match (publications)
"Bacterial Metabolites in Sustainable Agroecosystem", Springer Science and Business Media LLC, 2015
< 1% match (publications)
Fernandez, M.. "Fatty acid compositions of selected varieties of Spanish dry ham related to their nutritional implications", Food Chemistry, 2007
< 1% match (publications)
Yetti Marlida, Nazamid Saari, Zaiton Hassan, Son Radu, Jamilah Bakar. "Purification and characterization of sago starch-degrading glucoamylase from Acremonium sp. endophytic fungus", Food Chemistry, 2000
< 1% match (publications)
N N Barkah, Y Retnani, K G Wiryawan. " study of meal as protein source and its combination with the readily available carbohydrates for ruminant diet ", IOP Conference Series: Earth and Environmental Science, 2019
< 1% match (publications)
"Poster Presentations", Advances in Animal Biosciences, 2011
< 1% match (publications)
Lourenco, M.. "Influence of different dietary forages on the fatty acid composition of rumen digesta as well as ruminant meat and milk", Animal Feed Science and Technology, 20080814
< 1% match (publications)
Saeid Jafari, Yong M. Goh, Mohamed A. Rajion, Mahdi Ebrahimi, Mohammad F. Jahromi. "Dietary supplementation with papaya (Carica papaya L.) leaf affects abundance of rumen methanogens, fermentation characteristics and blood plasma fatty acid composition in goats", Spanish Journal of Agricultural Research, 2018
< 1% match (publications)
Ulrike C. Sauerwald. "Effect of Different Levels of Docosahexaenoic Acid Supply on Fatty Acid Status and Linoleic and α-Linolenic Acid Conversion in Preterm Infants : A Randomized Clinical Trial", Journal of Pediatric Gastroenterology & Nutrition, 10/2011
< 1% match (publications)
Yannisa Pertiwi, Afriani Sandra, Aronal Arief Putra. "Karakteristik Permen Jeli Susu Kambing yang Ditambahkan Berbagai Konsentrasi Jus Kulit Buah Naga Merah (Hylocereus polyrhizus)", Journal of Livestock and Animal Health, 2019
< 1% match (publications)
Aline F. O. Ramos, Stephanie A. Terry, Devin B. Holman, Gerhard Breves et al. "Tucumã Oil Shifted Ruminal Fermentation, Reducing Methane Production and Altering the Microbiome but Decreased Substrate Digestibility Within a RUSITEC Fed a Mixed Hay – Concentrate Diet", Frontiers in Microbiology, 2018
< 1% match (publications)

Mardiati Zain, Rusmana W S Ningrat, Erpomen, Ezi Masdia Putri, Malik Makmur. " The effects of leguminous supplementation on ammoniated rice straw based completed feed on nutrient digestibility on microbial protein synthesis ", IOP Conference Series: Earth and Environmental Science, 2019
< 1% match (publications)
Hussein Al-Hazmi, Jacek Namie.snik, Marek Tobiszewski. "Application of TOPSIS for Selection and Assessment of Analytical Procedures for Ibuprofen Determination in Wastewater", Current Analytical Chemistry, 2016
< 1% match (publications)
Antonio Natalello, Gonzalo Hervás, Pablo G. Toral, Giuseppe Luciano et al. "Bioactive compounds from pomegranate by-products increase the in vitro ruminal accumulation of potentially health promoting fatty acids", Animal Feed Science and Technology, 2019
< 1% match (publications)
Roni Ridwan, Iman Rusmana, Yantyati Widyastuti, Komang G. Wiryawan, Bambang Prasetya, Mitsuo Sakamoto, Moriya Ohkuma. "Fermentation Characteristics and Microbial Diversity of Tropical Grass-legumes Silages", Asian-Australasian Journal of Animal Sciences, 2015
< 1% match (publications)
Jayanegara, A., M. Kreuzer, and F. Leiber. "Ruminal disappearance of polyunsaturated fatty acids and appearance of biohydrogenation products when incubating linseed oil with alpine forage plant species in vitro", Livestock Science, 2012.
< 1% match (publications)
M. Ebrahimi. "Impact of different inclusion levels of oil palm (Elaeis guineensis Jacq.) fronds on fatty acid profiles of goat muscles : Oil palm frond and chevon fatty acid profile", Journal of Animal Physiology and Animal Nutrition, 08/2011
< 1% match (publications)
D. Gruffat, D. Durand, D. Rivaroli, I.N. do Prado, S. Prache. "Comparison of muscle fatty acid composition and lipid stability in lambs stall-fed or pasture-fed alfalfa with or without sainfoin pellet supplementation", animal, 2019
< 1% match (publications)
Gallardo, Maria A., Dirk Dannenberger, Jordana Rivero, Ruben Pulido, and Karin Nuernberg. "Fatty acid profile of plasma, muscle and adipose tissues in Chilota lambs grazing on two different low quality pasture types in Chiloé Archipelago (Chile) : Fatty Acids in Tissues of Pasture-Fed Lambs", Animal Science Journal, 2014.
< 1% match (publications)
Steinshamn, H.. "Performance and meat quality of suckling calves grazing cultivated pasture or free range in mountain", Livestock Science, 201008
< 1% match (publications)
Jafari, Saeid, Goh Yong Meng, Mohamed Ali Rajion, Mohammad Faseleh Jahromi, and Mahdi Ebrahimi. "MANIPULATION OF RUMEN MICROBIAL FERMENTATION BY POLYPHENOL RICH SOLVENT FRACTIONS FROM PAPAYA LEAF TO REDUCE GREEN-HOUSE GAS METHANE AND BIOHYDROGENATION OF C18 PUFA", Journal of Agricultural and Food Chemistry
< 1% match (publications)
"Theatre presentations", Advances in Animal Biosciences, 2011
< 1% match (publications)
J. Szczechowiak, M. Szumacher-Strabel, M. El-Sherbiny, E. Pers-Kamczyc, P. Pawlak, A. Cieslak. "Rumen fermentation, methane concentration and fatty acid proportion in the rumen and milk of dairy cows fed condensed tannin and/or fish-soybean oils blend", Animal Feed Science and Technology, 2016
< 1% match (publications)
Václav Kudrna, Milan Marounek. "Influence of feeding whole sunflower seed and extruded linseed on production of dairy cows, rumen and plasma constituents, and fatty acid composition of milk", Archives of Animal Nutrition, 2007
< 1% match (publications)
T Sudarmadji, W Hartati. "Reassessment of forest area and its scoring as a permanent production forest", IOP Conference Series: Earth and Environmental Science, 2018
< 1% match (publications)
HÃ¶jer, A., S. Adler, K. Martinsson, S.K. Jensen, H. Steinshamn, E. Thuen, and A.-M. Gustavsson. "Effect of legumeâ€“grass silages and Î±-tocopherol supplementation on fatty acid composition and Î±-tocopherol, Î²-carotene and retinol concentrations in organically produced bovine milk", Livestock Science, 2012.
< 1% match (publications)
Matthias Schmutz, Peter Weindl, Salome Carrasco, Gerhard Bellof, Eggert Schmidt. "The effects of breed, grazing system and concentrate supplementation on the fatty acid profile of the <i>musculus longissimus dorsi</i> and the kidney fat of steers", Archives Animal Breeding, 2014
< 1% match (publications)
El Hafidi. "POSSIBLE RELATIONSHIP BETWEEN ALTERED FATTY ACID COMPOSITION OF SERUM, PLATELETS, AND AORTA AND HYPERTENSION INDUCED BY SUGAR FEEDING IN RATS", Clinical and Experimental Hypertension, 2000
< 1% match (publications)
S. Marquardt, S. R. Barsila, S. L. Amelchanka, N. R. Devkota, M. Kreuzer, F. Leiber. "Fatty acid profile of ghee derived from two genotypes (cattle?yak vs yak) grazing different alpine Himalayan pasture sites", Animal Production Science, 2016
< 1% match (publications)
N.A. Khan, J.W. Cone, V. Fievez, W.H. Hendriks. "Causes of variation in fatty acid content and composition in grass and maize silages", Animal Feed Science and Technology, 2012
< 1% match (publications)
M. D. Fraser. "Effect on upland beef production of incorporating winter feeding of red clover silage or summer grazing of Molinia-dominated semi-natural pastures", Grass and Forage Science, 9/2007
< 1% match (publications)
Turner, T.D., J.L. Aalhus, C. Mapiye, D.C. Rolland, I.L. Larsen, J.A. Basarab, V.S. Baron, T.A. McAllister, H.C. Block, B. Uttaro, and M.E.R. Dugan. "Effects of diets supplemented with sunflower or flax seeds on quality and fatty acid profile of hamburgers made with perirenal or subcutaneous fat", Meat Science, 2015.
< 1% match (publications)
Jun Zhang, Alan D. Iwaasa, Guodong Han, Chen Gu, Hong Wang, Paul G. Jefferson, Justin Kusler. "Utilizing a multi-index decision analysis method to overall assess forage yield and quality of C3 grasses in the western Canadian prairies", Field Crops Research, 2018
< 1% match (publications)
Khiaosa-ard, R.. "Influence of alpine forage either employed as donor cow's feed or as incubation substrate on in vitro ruminal fatty acid biohydrogenation", Livestock Science, 201109
< 1% match (publications)
Romeu-Nadal, M.. "Oxidation stability of the lipid fraction in milk powder formulas", Food Chemistry, 2007
< 1% match (publications)
KAMILA M. DIAS, DANIEL SCHMITT, GISELLE R. RODOLFO, FRANCISCO C. DESCHAMPS et al. "Fatty acid profile in vertical strata of elephant grass subjected to intermittent stocking", Anais da Academia Brasileira de Ciências, 2017
< 1% match (publications)
Dewhurst, R. J., and A. P. Moloney. "Modification of animal diets for the enrichment of dairy and meat products with omega-3 fatty acids", Food enrichment with omega-3 fatty acids, 2013.
< 1% match (publications)
A. M. WACHIRA, L. A. SINCLAIR, R. G. WILKINSON, K. HALLETT, M. ENSER, J. D. WOOD. " Rumen biohydrogenation of -3 polyunsaturated fatty acids and their effects on microbial efficiency and nutrient digestibility in sheep ", The Journal of Agricultural Science, 2001
< 1% match (publications)

B I O D I V E R S I T A S ISSN: 1412-033X Volume 20, Number 7, July 2019 E-ISSN: 2085-4722 Pages: 1917-1922

DOI: 10.13057/biodiv/ d200718

Fatty acids composition and biohydrogenation reduction agents of tropical forages

MALIK MAKMUR1,?, MARDIATI ZAIN2,??, YETTI MARLIDA2, KHASRAD2, ANURAGA JAYANEGARA3 1Faculty of Animal Science, Universitas Andalas. Jl. Unand, Kampus Limau Manis, Padang 25163, West Sumatra, Indonesia. Tel./fax. +62-751-71464, ?email: malikmakmur27@gmail.com 2Department of Animal Nutrition, Faculty of Animal Science, Universitas Andalas. Jl. Unand, Kampus Limau Manis, Padang 25163, West Sumatra, Indonesia. Tel./fax. +62-751-71464, ??email: mardiati@ansci.unand.ac.id 3Department of Animal Nutrition, Faculty of Animal Science, Institut Pertanian Bogor. Jl. Agatis, Kampus IPB Dramaga, Bogor 16680, West Java, Indonesia

Manuscript received: 13 May 2019. Revision accepted: 21 June 2019.

Abstract. Makmur M, Zain M, Marlida Y, Khasrad, Jayanegara A. 2019. Fatty acids composition and biohydrogenation reduction agents of tropical forages. Biodiversitas 20: 1917-1922. The study was conducted to determine the composition of fatty acids, measured rumen biohydrogenation reduction agents (total phenols and total tannins) content and selected promising plants in various species of tropical forages. Ten species of tropical forages, namely, Panicum maximum, Cynodon plectostachyus, Pennisetum purpurephoides, Pennisetum purpureum, Brachiaria decumbens, Glyricidia sepium, Calliandra calothyrsus, Stylosanthes guaianensis, Leucaena leucocephala and Indigofera zollingeriana were used in this study. The fatty acids composition (% of total identified fatty acids) which were dominant in grasses were C18: 3n-3 (29%), C16: 0 (28%) and C18: 2n-6 (23%). Whereas in legumes, the significantly higher composition of fatty acids was C18: 3n-3 (42%) followed by C16: 0 (17%) and C18: 2n-6 (17%). The average poly-unsaturated fatty acids (PUFA) composition in grasses was relatively lower (44.6%) than legumes (59%). Likewise the content of total phenols and total tannins (g/100g DM) of grasses (0.91 and 0.41) and legumes (1.72 and 0.70). The selection of the forage plant species was based on the criteria of PUFA composition and biohydrogenation reduction agents using TOPSIS method. The results obtained show that B. decumbens (grass) and I. zollingeriana (legume) had the highest preference value of 0.74 and 0.87, respectively. In conclusion, B. decumbens and I. zollingeriana are forage species that have potential to provide healthier ruminant products.

Keywords: Biohydrogenation reduction agents, fatty acids, tropical forages

INTRODUCTION

Nutrition manipulation is needed to produce healthier meat by increasing the content of polyunsaturated fatty acids (PUFA). PUFA are a category of essential fatty acids, and its availability must be supplied through a feed. The provision of forage-based feeds (grasses and legumes) can significantly increase the omega-3 content in ruminant meat when compared to concentrate-based feed (Daley et al. 2010; Ruechel, 2012; Vahmani et al. 2015). With the increase in the proportion of PUFA in meat, it reduces the level of saturated fatty acids (SFA), and the ratio of PUFA: SFA in meat increases. Poulson et al. (2004), suggested that the conjugated linoleic acid (CLA) content of musculus longissimus of Angus crossing cattle increased five times that of CLA (cis-9, trans-11 C18: 2) isomer during the pasture-based finisher period. Where CLA intake plays an important role in maintaining human health through its role as anticarcinogenic. PUFA consumed by ruminants most times undergo metabolic processes by rumen microbes that originate from the genus Butyrivibrio sp. The lipolysis and biohydrogenation processes that occur in the rumen system make unsaturated fatty acids to be converted to saturated fatty acids, especially stearic acid (C18: 0) and a small portion of vaccenic acid (trans-11 C18: 1). Extensive biohydrogenation activity causes 90% of PUFA to be ineffectively deposited in meat and milk (Jayanegara et al. 2011a; Shingfield et al. 2010; Lourenco et al. 2010; Enjalbert et al. 2017). Forage as diets for ruminants, contains PUFA which is dominant in α-linolenic (C18: 3n-3) and linoleic forms (C18: 2 n - 6). Although the lipid content in forage is relatively small, it plays a central role in forming the composition of fatty acids in ruminant meat. Furthermore, the components of the secondary metabolite plant such as phenols and tannins which have antibiotic effects on rumen biohydrogenation microbes, bound complexes with macronutrients, and increase PUFA accumulation (Dewhurst et al. 2003; Lourenco et al. 2007; Jayanegara et al. 2011a; Jafari et al. 2016; Vasta et al. 2019). Studies on the increase of PUFA content in livestock products through forage-based feed are still limited to feed crop species that grow in sub-tropical regions. While in the tropical forage, this study tends to be forgotten because forage is still considered a source of fiber and its strategic function as a source of quality feed that is able to improve the quality of livestock products is not yet known. Therefore, further verification is needed. An in vitro study conducted by Jayanegara et al. (2011a), in 27 species of tropical forages revealed the potential of tropical forage in modulating biohydrogenation and increasing flow of C18: 3n-3 and C18: 2n-6 through the rumen. However, several plant species which are used as the main source of tropical forage is still lacking information. Considering the high biodiversity of forage species in tropical areas, forage- based systems is the most inexpensive, sustainable and adaptable method for small farmers in the tropical region. Therefore, a strategic study of the exploration of tropical forage species in terms of the fatty acid composition aspect and the content of biohydrogenation reduction agents is crucial. The objective of this study was to evaluate the composition of fatty acids (SFA, MUFA, and PUFA) and the composition of biohydrogenation reduction agents (total phenols and total tannins) found in each tropical forage species (grass and legume), which is valuable information for determining promising species to modify biohydrogenation and improve fatty acid profile.

MATERIALS AND METHODS Location The forage sample collection was carried out at BPTU- HPT Padang Mengatas, Indonesia during September 2018 where the average rainfall is 1800 mm/year, the temperature range from 18-28oC and average air humidity is about 70%. The station is located at an altitude between 700-900 meters above sea level. The soil type is podzolic (red-yellow), with pH of 5.6, and clay texture. Forages samples collection Samples of 10 tropical forages were collected from pasture area in BPTU-HPT Padang Mengatas, Indonesia. The collected forages are species that are generally used as sources of forage in the tropics. The 10 species which consisted of five grass species (Panicum maximum, Cynodon plectostachyus, Pennisetum purpurephoides, Pennisetum purpureum, Brachiaria decumbens) and five legume species (Glyricidia sepium, Calliandra calothyrsus, Stylosanthes guaianensis, Leucaena leucocephala, Indigofera zollingeriana). Each species collected weighed 3 kg of biomass and consisted of leaves and edible parts. They were stored indoors for 3 days and dried in an oven at 60oC for 3 h. They were then mashed by pressing them through a filter (of 1 mm mesh size). The smashed samples were put into an air-tight plastic pack and were stored until they were analyzed. Extraction of samples and their chemical analysis Extraction and quantification of total phenols and total tannins were estimated according to the procedure of Makkar (2003). Test tubes that contained 1 g of each sample received 10 mL of the solution, before they were put in a beaker that had been filled with distilled water and was placed in a water bath; and ultrasonicated for 20 min at room temperature. Each sample was centrifuged for 10 min at 3000 rpm and 4oC. The resulting supernatant was poured into another test tube. The remaining residues were extracted again using 2.5 mL of acetone 70% (v/v) using the same extraction procedure. Analysis of total phenols and total tannins was done using a standard solution of 0.1 mgmL-1 tannins acid. As well as adding polyvinylpolypyrrolidone to separate tannins from non-tannin phenols and the resultant was then read using UV- Vis spectrophotometer (U-1800-5930482, High-Technologies Corporation, Tokyo, Japan) with a wavelength of 724 nm. The total phenols and total tannins are expressed in g/100g dry matter (DM). Analysis of crude protein and crude fat content was done following the standard procedure of AOAC (2005). Determinations of neutral detergent fiber were quantified according to Van Soest et al. (1991). Determination of fatty acid composition Determination of the fatty acid composition of the forage samples was preceded by preparation of a standard solvent based on AOCS (1993) method, and the extraction of lipid and preparation of fatty acid methyl esters (FAME) was done through transmethylation of FAME using gas chromatography, according to the procedure of AOAC (2000). The prepared FAME was then analyzed using gas chromatography (model Agilent 7890B, Agilent Technologies, Inc., USA), equipped with Supelco SPTM 2560 capillary column (100m x 0.25 mm x 0.2 μm) to separate the methyl ester; and was detected by a flame ionized detector (FID). Ramping temperature setting up to 30oC/min with 3 running ramps. The injectors and detectors were set at 225 and 240oC, respectively. High purity nitrogen (N2) was used as a carrier gas with a flow rate of 18 cm/sec and split of 1: 100. Identification of fatty acid in the sample was achieved by matching the retention times with FAME standards. The fatty acid concentration was interpreted as a percentage (%) of the total identified fatty acids. Data analysis Data analyses were done according to the technique for order of preference by similarity to ideal solution (TOPSIS) method (Yoon and Hwang 1981). The stages of data analyses are as folows: (i) Establishment of assessment attributes in determining forage species that have the potential to reduce biohydrogenation activity based on literature investigations. (ii) Establishment of the attribute weight (%) with details of 50% PUFA composition and 50% biohydrogenation reduction agent (25% total phenols and 25% total tannins). (iii) Determination of a normalized decision matrix from a predetermined decision matrix. (iv) Determination of the positive ideal solution and the ideal negative solution from the weighted normalized decision matrix by identifying the maximum value or the minimum value based on the criteria for PUFA composition and the content of the biohydrogenation reduction agent for each species. (v) Determination of the separation or distance approach between the values of each alternative with a positive ideal solution and a negative ideal solution. (vi) Determination of the preference value for each species by combining the calculation between the distance of the alternative approach of the positive ideal solution and the alternative distance from the negative ideal solution. (vii) Ranking of forage species based on the preference value. MAKMUR et al. – Fatty acids composition of tropical forages 1919 RESULTS AND DISCUSSION conservation, and application of nitrogen fertilization. Khan et al. (2015), revealed that there was a large variation Fatty acid composition in PUFA content in tropical forage species but are Forage type had a significant influence on the relatively similar to fatty acid composition. The selection composition of the fatty acids. In grass species (Table 1), of forage species is one of the effective strategies in the average composition of C18: 3n-3 (29%) was higher improving the quality of fatty acid profiles in meat and than C16: 0 (28%) and C18: 2n-6 (23%). With the milk by taking into account the fatty acid content, PUFA composition of C18: 3n-3, the highest was B. decumbens composition, and polyphenol content (Guerra-Rivas et al. (40.52%) and the lowest was P. maximum (8.98%). The 2013; Patino et al. 2015). The vegetative growth stage is highest PUFA composition in the grass was B. decumbens the optimal condition in harvesting forages where the (60.81%), higher than P. purpuphoides (49.67%) and the highest PUFA and crude protein content is reached at this lowest was P. purpureum (34.05%). stage and will decrease when entering the generative stage Likewise, legume species (Table 2)

where C18: 3n-3 (Dewhurst et al. 2001; Buccioni et al. 2012). Forage (42%) significantly dominated,

followed by C16: 0 (17%) conservation such as hay and ensilage causes a decrease in and C18: 2n-6 (17%). The

highest C18-3n-3 composition essential fatty acids in plants due to the endogenous was C. calothyrsus (53.60%) and the lowest was S. lipolysis of PUFA (Dewhurst et al. 2006). The treatment of guaianensis (29.61%). The highest PUFA composition was N fertilizer in forages was able to influence the fatty acid found in the legume species C. calothyrsus concentration by increasing the leaf/stem ratio where the (74.58%),higher than I. zollingeriana (63.25%) and the leaf component was richer in the C18: 3n-3 content when lowest was L. leucocephala (49.85%). compared to other plant

components (Witkowska et al. The results of this study are in accordance with 2008). The results of

this study have implications that Clapham et al. (2005), Jayanegara et al. (2011a), Khan et tropical

forage feed has a high composition of essential al. (2015), Sultana et al. (2015) and Dias et al. (2017) who fatty acids C18: 3n-3. Therefore, it can increase the reported that the composition of C18: 3n-3 most dominated

biosynthesis of omega-3 long chain fatty acids such as forage fatty acid profile and was followed by

C16: 0 and eicosapentaenoic acid (EPA) and docosahexaenoic acid C18: 2n -6. There are four main

factors that influence the (DHA) in animal tissues. composition of fatty acids in forage (Clapham et al. 2005; Khan et

al. 2012): plant species, growth stages Table 1. Fatty acid profile of the grasses species (%)

Fatty acids P. maximum C. plectostachyus P. purpurephoides P. purpureum B. decumbens s.e.m. C14: 0 2.3 2.2 1.0 1.8 2.7 0.6 C16: 0 24.0 27.1 20.6 23.0 22.2 2.4 C18: 0 4.4 3.5 3.3 4.7 3.0 0.7 C18: 1n-9 11.7 8.9 7.9 5.0 5.8 2.7 C18: 2n-6 24.8 24.1 15.7 12.8 20.3 5.2 C18: 3n-3 9.0 17.0 34.0 20.1 40.5 12.9 C20: 0 1.5 1.9 3.2 6.8 1.0 2.3 Total SFA 50.0 50.0 42.4 61.0 33.4 10.2 Total MUFA 12.4 8.9 7.9 5.0 5.8 2.9 Total PUFA 37.6 41.1 49.7 34.0 60.8 10.7 n-6: n-3 2.8 1.4 0.5 0.6

0.5 1.0 Note: SFA-saturated fatty acid, MUFA- monounsaturated fatty acid, PUFA-polyunsaturated fatty acid, n-6: n-

3- ratio C18: 2n-6: C18: 3n-3, s.e.m .-standard error of the mean Table 2. Fatty acid profile

of the legumes species (%) Fatty acids G. sepium C. calothyrsus S. guaianensis L. leucocephala I.

zollingeriana s.e.m. C14: 0 C16: 0 C18: 0 C18: 1n-9 C18: 2n-6 C18: 3n-3 C20: 0 Total SFA Total MUFA Total

PUFA n-6: n-3 1.1 0.3 21.1 6.4 8.7 2.6 5.0 4.6 11.6 20.8 43.2 53.6 2.4 2.0 39.2 19.0 5.1 6.4 55.6 74.6 0.3 0.4 1.6 2.3 18.4 19.6 6.9 8.0 7.0 8.5 22.6 13.6 29.6 36.3 1.9 2.4 40.4 41.4 7.4 8.7 52.2 49.9 0.8 0.4 1.5 17.3 4.2 4.3 15.4 47.9 1.8 32.4 4.3 63.3 0.3 0.7 5.9 2.6 1.8 4.7 9.4 0.3 9.3 1.8 10.0 0.2 Note: SFA-saturated fatty acid, MUFA- monounsaturated

fatty acid, PUFA-polyunsaturated fatty acid, n-6: n-3- ratio C18: 2n-6: C18: 3n-3, s.e.m .-standard

error of the mean Biohydrogenation reduction agents The total phenols content of tropical forages ranges from 0.45 to 2.65 g/100 g DM (Table 3). Among the grass species studied, the content of total phenols was highest in P. purpureum (1.98) and lowest in C. plectostachyus (0.45). In legume species, L. leucocephala (2.65) had the highest total phenols content and the lowest was recorded in C. calothyrsus (0.66). In this study, phenols concentrations tend to be lower but concentration was not the main factor in suppressing biohydrogenation activity; rather it is the phenols composition itself (Jayanegara et al. 2011a). In tropical plants, phenolic components have a more massive concentration than plants in temperate climates.This is caused by exposure to ultraviolet rays in high intensity (Berli et al. 2011). In vitro studies have shown convincing results that the phenolic component can reduce C18: 0 accumulation in rumen fluid and increase

conjugated linoleic acid (CLA) isomers (Vasta et al. 2009; Ishlak et al. 2015; Buccioni et al. 2017).

The same results were shown in an in vivo study where polyphenol supplementation affected the biohydrogenation of

PUFA and the composition of the rumen microbiota by increasing intermediate fatty acids such as cis-9, trans -11

C18: 2 (Vasta et al. 2010; Andres et al. 2016; Yusuf et al. 2017). More specifically, one form of phenolic components such as condensed tannins and hydrolyzable tannins each plays a role in inhibiting various stages of biohydrogenation (Costa et al. 2018). The formation of the tannin-protein complex has also been reported to reduce the effects of negative lipolysis and rumen PUFA metabolism (Cabiddu et al. 2010). The phenolic compounds have been shown to modify the biohydrogenation and methanogenesis pattern of rumen through anti-microbial ability and the formation of

phenols-lipid complexes (Smith et al. 2005; He et al. 2006; Carreño et al. 2015). In vitro rumen fermentation studies revealed the potential of the phenols component as a biohydrogenation reduction agent capable of modifying ruminal lipid metabolism by suppressing the disappearance of essential fatty acid groups such asC18: 3n-3,

C18: 2n-6 and C18: 1n-9; also appearance of C18: 0 in the rumen system (Jayanegara et al. 2011a;

Jafari et al. 2016). The implication is that phenolic components contained in tropical forages can increase the transfer of PUFA in a feed to livestock products more effectively. Determination of the preferred forage species Figure 1.means that the forage of B. decumbens grass species has the greatest relative preference distance, which is equal to 0.74, followed by P. purpureum 0.64, P. purpurephoides 0.25, C. plectostachyus 0.12, and P. maximum 0.09. These results suggest that B. decumbens is the best solution for selecting tropical grass species which suggest that B. decumbens is the best solution for selecting tropical grass species which is appropriate as a forage- based ration material which is expected to reduce

biohydrogenation and improve the quality of ruminant products through improved fatty acid profiles. Table

3.Contens of crude protein, crude fat, neutral detergent fiber, total phenols and total tannins (g/100g DM) Forage species P. maximum C. plectostachyus P. purpurephoides P. purpureum B. decumbens G. sepium C. calothyrsus S. guaianensis L. leucocephala zollingeriana s.e.m. Sample Crude Crude type NDF Total Total protein fat phenols tannins Grass 7.55 1.41 66.05 0.46 0.12 Grass 9.64 1.78 68.72 0.45 0.02 Grass 13.07 2.42 66.02 0.5 0.03 Grass 7.02 2.51 64.01 1.98 0.94 Grass 17.50 2.70 53.67 1.19 0.94 Legume 25.20 3.96 35.73 1.11 0.19 Legume 28.46 4.11 50.72 0.66 0.16 Legume 17.91 2.92 41.45 1.98 0.86 Legume 25.15 4.80 31.63 2.65 1.15 Legume 31.90 3.64 21.91 2.46 1.13 9.0 1.0 16.6 0.9 0.5 Note: s.e.m.-standard error of the mean, NDF-neutral detergent fiber Figure 1.Preference value of grass species Figure 2.Preference value of legume species Figure 2 presents data on preference values among tropical legume species where the greatest preference value was achieved by species I. zollingeriana which was equal to 0.87, followed by L. leucocephala 0.77, C. calothyrsus 0.50, G. sepium 0.49 and S. guaianensis 0.44. These results indicate that I. zollingeriana promises the right tropical MAKMUR et al. – Fatty acids composition of tropical forages 1921 legume species to reduce the negative effect of biohydrogenation and increase PUFA bypass flow. Until now, there have been no studies that measure the extent to which these selected species are able to modulate rumen lipid metabolism. However, the study of Suharlina et al. (2016) revealed a strong indication in I. zollingeriana where supplementation in the range of 20-80% of rations was able to suppress methane production and total production of rumen gas which positively correlated with the biohydrogenation process. The utilization of hydrogen (H2) and carbon dioxide (CO2) substrates simultaneously is the main relationship between the process of methanogenesis and biohydrogenation (Lourenco et al. 2010). Interestingly, biohydrogenation reduction agents have the same inhibitory characteristics of the rumen methanogenesis pathways (Jayanegara et al. 2011b). Furthermore, the ability of based feed I. zollingeriana is able to modify fermentation and rumen degradation activities more

efficiently and improve the performance of ruminant livestock (Ginting et al. 2010; Tarigan et al. 2017;

Tarigan et al. 2018). Study of determining plant species based on the TOPSIS method has proven its

accuracy in identifying plant species on various assessment indicators (Alavi et al. 2012; Arabameri et al.

2014; Ariapour et al. 2014). Zhang et al. (2018), stated that TOPSIS based decision analysis is able to

accurately identify forage species that can produce optimal forage quality and biomass in varied land

conditions. We concluded that among tropical grass species, the PUFA composition of B. decumbens is the highest when compared to other grass species. While among tropical legume species, the PUFA composition of I. zollingeriana is the highest when compared to other legume species. In the content of biohydrogenation reduction agents, P. purpureum has the highest content in grasses and L. lecocephala species has the highest content in legumes. Whereas the best determination of tropical grass species and legumes, based on the criteria for PUFA composition and the content of biohydrogenation reduction agents are B. decumbens and I. zollingeriana. Both grass-legume species are expected to be the basis of diet which has potential to delivering PUFA more effectively into livestock products. ACKNOWLEDGEMENTS This study was

supported by PMDSU Grant by Ministry of Technology Research and Higher Education of Indonesia 2018. The research would not have been possible without the cooperation of technical and field assistance of the staffs in the BPTU-HPT Padang Mengatas and Laboratory of Ruminant Nutrition, Faculty of Animal Science of Andalas

University, Padang, Indonesia. REFERENCES Alavi I, Akbari A, Alinejad-Rokny H. 2012. Plant type selection for reclamation of Sarcheshmeh copper mine by fuzzy-TOPSIS method. AETA 1 (1): 8-13. Andrés A, Bodas R, Tejido ML, Giráldez FJ, Valdés C, López S. 2016. Effects of the inclusion of flaxseed and quercetin in the diet of fattening lambs on ruminal microbiota, in vitro, fermentation and biohydrogenation of fatty acids. J. Agric. Sci. 154: 542-552. AOAC. 2000. Official methods of analysis, Oil and Fat. 17th ed. The Association of Official Analytical Chemists.Washington, D.C., USA. AOAC. 2005. Official methods of analysis. 18th ed. The Association of Official Analytical Chemists. Maryland, USA. AOCS. 1993. Preparation of methyl esters of long-chain fatty acid composition by gas chromatography. In: Official methods of analysis. Association of Official Analytical Chemists. 15th ed. The Association of Official Analytical Chemists, USA. Arabameri A, Abbasi S, Eftekhari SM, Amouniya H. 2014. Selection the most suitable species type for stabilising sand dunes in dealing with the spread of desertification for environmental sustainability using TOPSIS method (Case study: Chah Jam Erg in South of Haj Ali Gholi Playa in Central part of Semnan Province, Iran). Elixir Geoscience 70: 23793-23798. Ariapour A, Veisanloo F, Asgari M. 2014. An application of fuzzy TOPSIS method for plant selection in rangeland improvement (case study: Boroujerd Rangeland, Lorestan Province, Iran). J. Range Sci. 4 (3): 183-194. Berli FJ, Fanzone M, Piccoli P, Bottini R. 2011. Solar UV-B and ABA are involved in phenol metabolism of Vitis vinifera L. increasing berry skin polyphenols. J. Agric. Food Chem. 59: 4874-4884. Buccioni A, Decandia M, Minieri S, Molle G, Cabiddu A. 2012. Lipid metabolism in the rumen: new insights on lipolysis and biohydrogenation with an emphasis on the role of endogenous plant factors. Anim. Feed Sci. Technol. 174: 1-25. Buccioni A, Pallara G, Pastorelli R, Bellini L, Cappucci A, Mannelli F, Minieri S, Roscini V, Rapaccini S, Mele M, Giovannetti L, Viti C, Pauselli M. 2017. Effect of dietary chestnut or quebracho tannin supplementation on microbial community and fatty acid profile in the rumen of dairy ewes. Biomed Res Intl 2017: 4969076. DOI: 10.1155/2017/4969076. Cabiddu A, Salis L, Tweed JKS, Molle G, Decandia M, Lee MRF. 2010. The influence of plant polyphenols on lipolysis and biohydrogenation in dried forages at different phenological stages: in vitro, study. J. Sci. Food Agric. 90: 829-835. Carreño D, Hervás G, Toral PG, Belenguer A, Frutos P. 2015. Ability of different types and doses of tannin extracts to modulate in vitro ruminal biohydrogenation in sheep. Anim. Feed Sci. Technol. 202: 42-51. Clapham W, Foster JG, Neel JPS, Fedders JM. 2005. Fatty acid composition of traditional and novel forages. J. Agri. Food Chem. 53: 10068-10073. Costa M, Alves SP, Cappucci A, Cook SR, Duarte A, Caldeira RM, McAllister TA, Bessa RJB. 2018. Effects of condensed and hydrolyzable tannins on rumen metabolism with emphasis on the biohydrogenation of unsaturated fatty acids. J. Agric. Food Chem. 66: 3367-3377. Daley CA, Abbott A, Doyle PS, Nader GA, Larson S. 2010. A review of fatty acid profiles and antioxidant content in grass-fed and grain-fed beef. Nutrition J 9: 10. pp. 1-12. Dewhurst R, Scollan N, Lee M, Ougham H, Humphreys M. 2003. Forage breeding and management to increase the beneficial fatty acid content of ruminant products. Proc Nutr Soc. 62 (2): 329-336. Dewhurst RJ, Shingfield KJ, Lee MRF, Scollan ND. 2006. Increasing the concentrations of beneficial polyunsaturated fatty acids in milk produced by dairy cows in high-forage systems. Anim. Feed Sci. Technol. 131: 168-206. Dias KM, Schmitt D, Rodolfo GR, Deschamps FC, Camargo GN, Pereira RS, Sbrissia AF. 2017. Fatty acid profile in vertical strata of elephant grass subjected to intermittent stocking. An. Acad. Bras. Cienc. 89 (3): 1707-1718. Enjalbert F, Combes S, Zened A, Meynadier A. 2017. Rumen microbiota and dietary fat: a mutual shaping. J. Appl. Microbiol. 123: 782-797. Ginting SP, Krisnan R, Krisnan J, Sirait J, Antonius. 2010. The utilization of Indigofera sp. as the sole foliage in goat diets supplemented with high carbohydrate or high protein concentrate. Indon J Anim Vet Sci (JITV) 15 (4): 261-268. Guerra-Rivas C, Lavín P, Gallardo B, Mantecón, AR, Vieira C, Manso T. 2013. Grape pomace and grape seed extract in lambs diet: meat fatty acid profile and antioxidant activity. In: Book of Abstract of the 64th AnnualMeeting of the European Federation of Animal Science. Wageningen Academic Publishers, Nederland. He Q, Shi B, Yao K. 2006. Interactions of gallotannins with proteins, amino acids, phospholipids and sugars. Food Chem 95: 250-254. Ishlak A, Günal M, AbuGhazaleh AA. 2015. The effects of cinnamaldehyde, monensin and quebracho condensed tannin on rumen fermentation, biohydrogenation and bacteria in continuous culture system. Anim. Feed Sci. Technol. 207: 31-40. Jafari S, Meng GY, Rajion MA, Jahromi MF, Ebrahimi M. 2016. Manipulation of rumen microbial fermentation by polyphenol rich solvent fractions from papaya leaf to reduce greenhouse gas methane and biohydrogenation of C18 PUFA. J. Agric. Food Chem. 64: 4522- 4530. Jayanegara A, Kreuzer M, Wina E, Florian L. 2011a. Significance of phenolic compounds in tropical forages for the ruminal bypass of polyunsaturated fatty acids and the appearance of biohydrogenation intermediates as examined in vitro. Anim Prod Sci 51: 1127-1136. Jayanegara A, Wina E, Soliva CR, Marquardt S, Kreuzer M, Leiber F. 2011b. Dependence of forage quality and methanogenic potential of tropical plants on their phenolic fractions as determined by principal component analysis. Anim. Feed Sci. Technol. 163: 231-243. Khan NA, Farooq MW, Ali M, Suleman M, Ahmad N, Sulaiman SM, Cone JW, Hendriks WH. 2015. Effect of species and harvest maturity on the fatty acids profile of tropical forages. J. Anim. Plant. Sci. 25 (3): 739-746. Khan NA, Cone JW, Fievez V, Hendriks WH. 2012. Causes of variation in fatty acid content and composition in grass and maize silages. Anim. Feed Sci. Technol. 174: 36-45. Lourenço M, Ramos-Morales E, Wallace RJ. 2010. The role of microbes in rumen lipolysis and biohydrogenation and their manipulation. Animal. 4: 1008-1023. Lourenco M, Van Ranst G, Vlaeminck B, De Smet S, Fievez V. 2007. Influence of different dietary forages on the fatty acid composition of rumen digesta as well as ruminant meat and milk. Anim. Feed Sci. Technol. 145: 418-437. Makkar HPS. 2003.Quantification of tannins in tree and shrub foliage: a laboratory manual. Kluwer Academic Publishers, Dordrecht. Patino HO, Medeiros FS, Swanson CH, Swanson KC, McManus C. 2015. Productive performance, meat quality and fatty acid profile of steers finished in confinement or supplemented at pasture. J Nurition. 134: 2407-2414. Poulson CS, Dhiman TR, Ure AL, Cornforth D, Olson KC. 2004. Conjugated linoleic acid content of beef from cattle fed diets containing high grain, CLA, or raised on forages. Livest. Prod. Sci. 91: 117-128. Ruechel J. 2012. Grass-fed cattle: how to produce and market natural beef. Storey Books, North Adams, MA. Shingfield KJ, Bernard L, Leroux C, Chilliard Y. 2010. Role of trans fatty acids in the nutritional regulation of mammary lipogenesis in ruminants. Animal. 4: 1140-1166. Smith AH, Zoetendal E, Mackie RI. 2005. Bacterial mechanisms to overcome inhibitory effects of dietary tannins. Microb Ecol 50: 197- 205. Suharlina, Astuti DA, Nahrowi, Jayanegara A, Abdullah L. 2016. Nutritional evaluation of dairy goat rations containing Indigofera zollingeriana by using in vitro rumen fermentation technique (RUSITEC). Intl. J. Dairy Sci. 11: 100-105. Sultana N, Alimon AR, Huque KS, Sazili AQ, Yaakub H, Hussain SMJ, Das NG. 2017. Study of Anti-nutritional Compounds, Antioxidant Activity and Fatty Acid Composition of Moringa (Moringa oleifera Lam.) Foliage. Asian J Agric Food Sci 5 (3): 144-150. Tarigan A, Ginting SP, Arief II, Astuti DA, Abdullah L. 2017. Physical quality and digestibility in vitro determination of green concentrate based on Indigofera zollingeriana. Indon J Anim Vet Sci (JITV) 22 (3): 114-123. Tarigan A, Ginting SP, Arief II, Astuti DA, Abdullah L. 2018. Body weight gain, nutrients degradability and fermentation rumen characteristics of boerka goat supplemented green concentrate pellets (GCP) based on Indigofera zollingeriana. Pak. J. Biol. Sci. 21: 87-94. Vahmani P, Mapiye C, Prieto N, Rolland DC, McAllister TA, Aalhus J, Dugan MER. 2015. The scope for manipulating the polyunsaturated fatty acid content of beef: a review. J. Anim. Sci. Biotechnol. 2015: 6. DOI: 10.1186/s40104-015-0026-z. Van Soest PJ, Robertson JB, Lewis BA. 1991. Methods for dietary fiber, neutral detergent fiber, and nonstarch polysaccharides in relation to animal nutrition. J. Dairy Sci. 74: 3583-3597. Vasta V, Daghio M, Cappuci A, Buccioni A, Serra A, Viti C, Mele M. 2019. Plant polyphenols and rumen microbiota responsible for fatty acid biohydrogenation, fiber digestion, and methane emission: Experimental evidence and methodological approaches. J. Dairy Sci. 102: 1-24. Vasta V, Makkar HPS, Mele M, Priolo A. 2009. Ruminal biohydrogenation as affected by tannins in vitro. Br. J. Nutr. 102: 82- 92. Vasta V, Yáñez-Ruiz DR, Mele M, Serra A, Luciano G, Lanza M, Biondi L, Priolo A. 2010. Bacterial and protozoal communities and fatty acid profile in the rumen of sheep fed a diet containing added tannins. Appl. Environ. Microbiol 76: 2549-2555. Witkowska I, Wever C, Gort G, Elgersma A. 2008. Effects of nitrogen rate and regrowth interval on perennial ryegrass fatty acid content during the growing season. Agron. J. 100: 1371-1379. Yoon K, Hwang CL. 1981. Multiple Attribute Decision Making: Methods and Applications. Springer, Berlin. Yusuf AL, Adeyemi KD, Samsudin AA, Jafari YM, Alimon AR, Sazili AQ. 2017. Effects of dietary supplementation of leaves and whole plant of Andrographis paniculata on rumen fermentation, fatty acid composition and microbiota in goats. BMC Vet. Res. 13: 349. DOI: 10.1186/s12917-017-1223-0. Zhang J, Iwaasa AD, Han G, Gu C, Wang H, Jefferson PG, Kusler J. 2018. Utilizing a multi-index decision analysis method to overall asses forages yield and quality of C3 grasses in the western Canadian prairies. Field Crop Res 222: 12-25.