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RESEARCH ARTICLE

DIGESTIBILITY, MILK YIELD AND MILK QUALITY OF F_1 UPGRADED GOATS FED AZOLLA-BASED FORMULATED CONCENTRATE

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ABSTRACT

Azolla, a protein-rich aquatic fern, plays a vital role in goat nutrition due to its high digestibility and nutritional value and were utilized as a dietary protein source on the digestibility, milk yield, and milk quality of lactating upgraded goats. A 20 weeks (140 days) feeding trial with a 2 weeks acclimatization period was conducted using 16, first parity lactating 50% Anglo-Nubian x 50% Native goats in a Randomized Completely Block Design. Data were analyzed using analysis of variance and significant differences among treatments were determined using Tukey's Test at 5% level of significance. findings show that the final body weight of goats fed with formulation 4 (15% azolla) had significantly higher ($p<0.05$) final body weight of 31.75 kg compared to goats fed with formulation 1 (0% azolla) with 27.85 kg, but were comparable ($p>0.05$) to goats fed with formulation 3 (10% azolla) and formulation 2 (5% azolla) of 31.50 kg. Digestibility of feed and legumes was significantly higher ($p<0.05$) in goats fed with 5% azolla (90.76% and 77.06%, respectively) compared to the control, but comparable to those fed with 10% and 15% azolla. Milk analysis showed that the milk of goats fed with formulation 2 (5% azolla) had significantly higher ($p<0.05$) milk fat of 8.10 g/kg, protein of 4.80 g/kg, ash of 0.90 g/kg, Calcium of 204 mg/kg and 164 µg/kg compared to the milk quality of upgraded goats fed with other formulations. Additionally, goats fed with 5% azolla had the highest milk yield (696 ml/day) and profitability, with a net income of 788.85 and a return on investment of 18.80%. These findings suggest that incorporating 5% azolla in goat feed enhances growth performance, digestibility, and profitability, making it a viable strategy for improving goat production and income for farmers.

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INTRODUCTION

Goat production is a low-maintenance and cost-effective livestock enterprise, making it a viable source of income and nutrition, particularly for resource-poor families. Goats can thrive on diverse feed resources, including tree leaves, weeds, grasses, and agricultural by-products, requiring minimal initial investment and posing lower financial risks than other livestock species (Tacio, 2012). Additionally, their adaptability to various environments and efficient feed conversion make goat farming a promising venture for small-scale farmers. With the increasing demand for protein-rich food sources, goat production plays a crucial role in addressing food security and income generation in the Philippines. In terms of milk production efficiency, goats outperform cows when comparing the amount of milk produced per unit of nutrients consumed. The nutrient conversion efficiency in dairy goats is approximately 45.71%, compared to 38% in dairy cows. Moreover, goats exhibit superior crude fiber utilization compared to other ruminants, being 4.0% more efficient than sheep, 7.9% more efficient than buffaloes, and 8.6% more efficient than cows (Stergiadis *et al.,* 2019). Goat milk also offers significant benefits for human nutrition, particularly in alleviating malnutrition in developing countries, serving as an alternative for individuals with cow milk allergies and gastrointestinal disorders, and catering to a growing market of premium dairy consumers (Haenlein, 2004).

However, the rising cost of commercial milk enhancers in the Philippines presents a challenge for small-scale dairy producers, necessitating alternative feed options that enhance milk yield and quality without increasing production costs. Azolla, a floating aquatic fern is a promising organic feed substitute due to its high nutritional value and low cost (Rieta and Cabaral, 2018; Cabaral and Rieta, 2020). Azolla hosts a symbiotic blue-green alga which enables biological nitrogen fixation, making it an excellent protein source (Bacchu, *et. al.,* 2017; Pillai *et al.,* 2005). With a protein content of 25.97% (Rieta and Cabaral, 2018; Cabaral and Rieta, 2020) with different CP ranges from 20-30% (Ahmed *et al.,* 2016; Ahorwar and Leela, 2012; El Naggar and El-Mesery, 2022) on a dry weight basis, azolla is also rich in essential minerals such as iron, calcium, magnesium, phosphorus, copper, and manganese, along with significant amounts of vitamins A, B12 and beta-carotene (Ndegwa, 2015). Its high digestibility, low lignin content, probiotic properties, and essential amino acids content such as Met, Thr, Arg, Val, Ile, Trp, Cys, Gly, Ser, Tyr, Phe, Ala, His, Pro, Trp and Asp are glucogenic which can be converted to glucose which enhances milk production, milk quality and overall animal health (El Naggar and El-Mesery, 2022; Murthy *et al.,* 2013; Huggins, 2007; Leterme *et al.,* 2009). Given its potential, this study aims to evaluate the effects of different levels of azolla inclusion in formulated concentrates on the digestibility, milk yield, and milk quality of upgraded goats. Specifically, the study will assess the impact of azolla on feed digestibility, milk composition (fat, protein, minerals, and vitamins),

and the economic viability of using azolla-based feeds in goat production.

MATERIALS AND METHODS

Materials: The study was conducted on October 28, 2021 to March 31, 2022 at Goat Production Project, Mindoro State University, Victoria, Oriental Mindoro while analysis for the milk quality was conducted at Food and Nutrition Research Institute (FNRI). Crude Protein analysis of the azolla-based formulated concentrate was analyzed in the Animal Feed laboratory and Analytical Laboratory, Mindoro State University. A total of 16, first parity, lactating F1 Anglo-Nubian and Native goats (50%AN:50 Native) was utilized in the study, oven dried azolla, SBOM, Copra meal, corn grits, feed wheat, salt, Dicalphos, Molasses, RBD1, legumes (*ipil-ipil* and *kakawate*), napier grass, hand gloves, used sacks, face masks, milk bucket, 4 cages, calculator, digital weighing scale, analytical weighing scale, forage oven, 4 pcs feeding trough and watering trough, fumigant, ice box, record notebook and ballpen, shovel and rake, broom and dust pan, and bolo.

Methods

Experimental Design and Treatment: The goats were equally and randomly distributed into four dietary azolla-based formulated concentrates, fed for 20 weeks (140 days) feeding trial with a 2 weeks acclimatization period using 16, first parity lactating 50% Anglo-Nubian x 50% Native goats in a Randomized Completely Block Design with age (block 1 - 543 days old; block 2 - 546 days old; block 3 – 549 days old; block 4 – 552 days old) as the blocking factor (i.e., initial weight is comparable) with four (4) replications.

Table 1. Azolla-based Formulated concentrate used in the study (parts per hundred)

Feedstuffs	Formulation 1	Formulation 2	Formulation 3	Formulation 4
Rice bran D1	23.500	20.500	20.550	17.550
Azolla	0.000	5.000	10.000	15.000
Corn grits	21.000	24.350	24.900	28.500
Feed wheat	2.000	2.000	2.000	2.000
Copra meal	28.720	24.300	21.000	15.000
SBOM	12.730	11.370	9.500	8.650
Molasses	10.050	10.480	10.050	11.300
Salt	1.000	1.000	1.000	1.000
Dicalphos	1.000	1.000	1.000	1.000
Crude Protein	*14.464*	*14.465*	*14.466*	*14.467*

Treatment Implementation. After the arrival of the Upgraded goats, it was acclimatized for one week. Afterwards, goats were weigh individually and randomly distributed into four treatments. Legumes and Napier grass were collected early in the morning (5:30 am) and late in the afternoon (4:00 pm) using cut-and-carry method and were fed to the goats 30 minutes after cutting to reduce the moisture content and prevent parasitic infestation. The azolla was collected at the Azolla production area (Azolla pond), Mindoro State University and was oven dried at the temperature of 70°C about 12 to 24 hours. The feeding schedule is the AM:PM rule (twice a day). The goats were provided with four dietary formulated concentrate (20%), legumes preferably *kakawate* (10%) and *ipil-ipil* (10%) and napier grass (60%) based on the dry matter requirement of the animal (3% of the animal's body weight) and was recomputed every feeding trial cycle. Clean drinking water was made available while goat health and good body condition was ensured throughout the duration of the study. To facilitate the separate digestibility of the feedstuff, the feeding guide applied by the Small Ruminant Center, Central Luzon State University (CLSU) at Science City of Muñoz, Nueva Ecija was implemented. The formulated concentrate was given first and was provided to goats for 30 minutes. Afterwards, feed refusal was collected and recorded. Likewise, grass was provided after the provision of formulated concentrate and was provided to goats for additional 30 minutes. Then grass refusal was also collected, weigh and recorded. After the provision of formulated concentrate and grasses, *kakawate* and *ipil-ipil* were also given for 30 minutes and then refusal was collected afterwards.

Milking: Prior to milking, proper sanitation and hygiene is observed within the experimental cages and goats was restrained in a milking stand to prevent movement. Hands was thoroughly washed with antibacterial soap, and the udder was cleaned using wet cheesecloth. After cleaning, the udder was dried with a clean, single-use cheesecloth. A few squirts of milk were stripped from each teat to check for abnormalities such as mastitis, blood or clots. Hand milking was performed. The teat is grasped at the base with the thumb and forefinger to trap milk in the teat canal. A progressive squeeze is then applied using the middle, ring, and pinky fingers to extract milk without pulling. This process was repeated in a rhythmic motion until the udder is emptied. After milking, post-milking procedures was done to maintain udder health and milk quality. A post-milking dip (iodine-based dip solution) was used and was applied to each teat to reduce the risk of mastitis. After collection, collected milk was immediate recorded and rapidly cooled to 4°C within 30 minutes to preserve quality. Afterwards, all equipment was clean and wash with hot water followed by thorough rinsing and drying (Wolford, 2017).

Data Gathering

Body Weight: The body weight was gathered using a hanging weighing scale before the conduct of the study and after the completion of each cycle which served as the basis on the computation of formulated concentrate, *ipil-ipil*, *kakawate* and napier grass.

***Digestibility*:** The digestibility of a feed determines the amount that is actually absorbed by an animal and therefore the availability of nutrients specifically for growth and reproduction, and other essential metabolic processes that affects overall goat productivity. Digestibility percentage was determined separately in formulated concentrate, legumes and grasses with the formula: Percentage digestibility = dry mater (DM) intake minus the DM weight of feces divided by the DM feed intake multiplied by 100.

Milk Quality: The collected milk per cycle was analyzed at the Food and Nutrition Research Institute (FNRI), Department of Science and Technology (DOST), Taguig City, Manila for testing and analysis of the milk in terms of total fat, total solid non-fat, protein, ash (mineral) content, calcium, and Vitamin A.

Cost and Return Analysis: Collected milk was sold per liter and slaughtered goats were sold per kg. The economics was determined using the cost and return analysis parameters such as net income, income per kilogram, income per Liter of milk and return on investment using the following formula: (a) Net income = total sales – total expenses; (b) Income per kilogram = Net income divided by the total kilogram of meat produced; (c) Income per liter of milk = Net income divided by the total liter of milk produced; and (d) Return on investment (ROI) = Net income divided by total expenses multiplied with 100.

Statistical Analysis: All data was collected, organized, encoded and tabulated. A Randomized Completely Block Design was used in assigning experimental animals per treatment replication as age as the blocking factor. Analysis of Variance (ANOVA) was used in analyzing all data sets to determine the significance of the results. In addition, treatment means were further analyzed to determine significance among treatment means using the Tukey's Test at 5% level of significance.

RESULT AND DISCUSSION

Body Weight: Results revealed similar ($p>0.05$) initial body weight among 1st parity lactating F_1 upgraded goats used in the conduct of the study (Table 2). On the other hand, findings show that the final

body weight of goats fed with formulation 4 (15% azolla) had significantly higher ($p<0.05$) final body weight of 31.75 kg compared to goats fed with formulation 1 (0% azolla) with 27.85 kg, but were comparable ($p>0.05$) to goats fed with formulation 3 (10% azolla) and formulation 2 (5% azolla) of 31.50 kg. The results can be associated to the fact that azolla is very high in proteins, essential amino acids, and growth promoter intermediaries and minerals like calcium, phosphorus, potassium, ferrous, copper, magnesium, and other nutrients necessary for efficient utilization of its nutrient components (El Naggar and El-Mesery, 2022; Murthy *et al.,* 2013; Huggins, 2007; Leterme *et al.,* 2009). Thus, the biocomposition of azolla makes it more efficient and economic feed substitutes for livestock. Moreover, azolla can be easily digested by livestock due to its high protein and low lignin content (Kathirvelan *et.al.,* 2015; Tran, 2015). In addition, azolla is very rich in vitamin A, vitamin B12 and Beta Carotene which serve as growth promoter intermediaries, hence improved livestock growth performance (El Naggar and El-Mesery, 2022; Ndegwa, 2018; Kathirvelan *et al.,* 2015; Ndegwa, 2015; Murthy *et al.,* 2013; Huggins, 2007; Leterme *et al.,* 2009). It also contains wide ranges of essential amino acids namely: Met, Thr, Arg, Val, Ile, Trp, Cys, Gly, Ser, Tyr, Phe, Ala, His, Pro, and Asp are which are glucogenic which means that these amino acids can be converted to glucose (El Naggar and El-Mesery, 2022; Bacchu *et al.,* 2017; Parashuramulu *et al.,* 2015), hence a very good source of energy, which consequently enhances the feed intake and the overall growth performance of ruminants.

On the other hand, results revealed comparable ($p>0.05$) grass digestibility (DOG) among goats fed with different formulated concentrate containing different levels of azolla in the dietary ration. Results conform to the findings of Roy *et al.,* (2016) that replacement of concentrate mixture with azolla at 5% level in Hariana heifers improved weight gain and digestion efficiency in the animal. Moreover, Ahirwar and Leela (2012), Ahmed *et al.,* (2016) and Roy *et al.,* (2016) reported that dried azolla can be incorporated 10-20% of the concentrate mixture to economize and maximized the potential of azolla in the ration without any adverse effect on growth performance and digestibility.

Milk Quality: After each cycle of feeding trial, milk sample was collected and was brought to Food and Nutrition Research Institute (FNRI), Bicutan, Taguig City for analysis. The AOAC procedure was done to determine the calcium and Vitamin A, ISI formula for the solid non-fat, acid hydrolysis using the soxhlet extractor for the milk total fat and the automated kjeldahl method using the Buchi was used for protein analysis. Analysis showed that the milk of goats fed with formulation 2 (5% azolla) had significantly higher ($p<0.05$) milk fat of 8.10 g/kg, protein of 4.80 g/kg, ash of 0.90 g/kg, Calcium of 204 mg/kg and 164 µg/kg compared to the milk quality of upgraded goats fed with other formulations (Table 4). These results can be attributed to the significantly higher ($p<0.05$) digestibility of feeds and legumes (Table 3) of goats fed with formulation 2 (5% azolla).

Table 2. Body Weight of Lactating Upgraded Goats Fed with Azolla-based Formulated Concentrate

DIETARY TREATMENT	Initial Body Weight	Final Body Weight
Formulation 1 (0% azolla)	25.250[a]	27.850[c]
Formulation 2 (5% azolla)	24.750[a]	31.500[a]
Formulation 3 (10% azolla)	25.500[a]	31.500[a]
Formulation 4 (15% azolla)	25.500[a]	31.750[a]

Legend: Means within column with different superscripts are significantly different (P<0.05)

Table 3. Feed, Grass and Legume Digestibility of Lactating Upgraded Goats Fed with Azolla-based Formulated Concentrate

DIETARY TREATMENT	DOF (%)	DOG (%)	DOL (%)
Formulation 1 (0% azolla)	86.311[b]	91.222[a]	63.996[b]
Formulation 2 (5% azolla)	90.756[a]	94.448[a]	77.061[a]
Formulation 3 (10% azolla)	88.386[ab]	92.868[a]	73.331[a]
Formulation 4 (15% azolla)	88.187[ab]	92.816[a]	69.949[ab]

Legend: Means within column with different superscripts are significantly different (P<0.05); DOF-digestibility of feeds; DOG; digestibility of grass; DOL; digestibility of legumes

Table 4. Milk Quality of Lactating Upgraded Goats Fed with Azolla-based Formulated Concentrate

DIETARY TREATMENT	MILK TOTAL FAT(g/kg)	SOLID NON-FAT (g/kg)	PROTEIN (g/kg)	ASH (g/kg)	CALCIUM (mg/kg)	VIT. A (µg/kg)
Formulation 1 (0% azolla)	6.70[b]	250.55[a]	3.90[b]	0.70[b]	154.00[b]	42.00[c]
Formulation 2 (5% azolla)	8.10[a]	250.63[a]	4.80[a]	0.90[a]	204.00[a]	164.00[a]
Formulation 3 (10% azolla)	7.30[ab]	250.58[a]	4.40[ab]	0.90[a]	192.00[a]	150.00[a]
Formulation 4 (15% azolla)	7.10[ab]	250.57[a]	4.30[ab]	0.80[ab]	157.00[b]	62.00[b]

Legend: Means within column with different superscripts are significantly different (P<0.05)

Table 5. Milk Yield of Lactating Upgraded Goats Fed with Azolla-based Formulated Concentrate

DIETARY TREATMENT	Milk yield (L/day)
Formulation 1 (0% azolla)	0.533[b]
Formulation 2 (5% azolla)	0.696[a]
Formulation 3 (10% azolla)	0.595[b]
Formulation 4 (15% azolla)	0.589[b]

Legend: Means within column with different superscripts are significantly different (P<0.05)

Digestibility of Feeds, Grass and Legumes*:* The digestibility of feeds, grass and legumes of upgraded goats fed with formulated concentrate containing different levels of azolla was presented in Table 3. Results revealed that upgraded goats fed with formulation 2 (5% azolla) had significantly higher ($p<0.05$) digestibility of feed (DOF) of 90.756% and digestibility of legumes of 77.061% compared to the DOF and DOL of upgraded goats fed with formulation 1 (0% azolla), but are comparable ($p>0.05$) to upgraded goats fed with formulation 3 (10% azolla) and formulation 4 (15% azolla).

These results can be associated to the findings of several researchers (El Naggar and El-Mesery, 2022; Anitha *et al.,* 2016; Murthy *et al.,* 2013; Parashuramulu *et al.,* 2013) who reported that azolla is rich in protein (20-30%), amino acids (i.e., Met, Thr, Arg, Val, Ile, Trp, Cys, Gly, Ser, Tyr, Phe, Ala, His, Pro, and Asp), vitamins, minerals, beta carotene which enhances feed and legume digestibility (i.e., efficient utilization of nutrient components) that eventually improved milk production and quality when included at an optimal level (Bacchu *et al.,* 2017; Roy *et al.,* 2016; Ahirwar and Leela, 2012; Ahmed *et al.,* 2016;).

Milk Yield. In terms of the milk yield, results revealed that upgraded goats fed with formulation 2 (5% azolla) has significantly higher ($p<0.05$) milk yield of 696 ml/day compared to the milk yield of upgraded goats fed with formulation 1 (0% azolla), formulation 3 (10% azolla) and fed with formulation 4 (15% azolla) with milk yield of 533ml/day, 595ml/day and 589ml/day, respectively. Results conform to the findings of Roy *et al.,* (2016) that replacement of concentrate mixture with azolla at 5% level in Hariana heifers improved weight gain, digestion efficiency, and the milk production in the animals. Results also showed that the upgraded goats used in the study with an average milk yield of 0.696 liters/day are within the ranged of milk yield of upgraded goats (50%Anglo-Nubian; 50% Native Goats) recorded at the Small Ruminant Center, central Luzon State University (SRC-CLSU) with 0.5-0.75 liters/day. Moreover, findings can be associated to the significantly higher ($p<0.05$) digestibility of feed and legumes of goats fed with formulation 2 (5% azolla) compared to the DOF and DOL of upgraded goats fed with other azolla-based formulated concentrate which consequently affects the feed intake, digestion efficiency and the milk production of the upgraded goats.

Economics. The economics of upgraded goats fed with different level of azolla in the formulated concentrate was recorded and shows that lactating upgraded goats provided with formulation 2 (5% azolla) in their dietary ration had the highest net income and return on investment with 788.85 and 18.80 that was significantly higher ($P<0.05$) from the profitability of raising lactating upgraded goats provided with formulation 1 (0% azolla), formulation 3 (10% azolla) and formulation 4 (15% azolla). These results can be probably had been due to the significantly higher ($p<0.05$) milk yield (Table 5) and feed and legumes digestibility of lactating goats provided with Treatment 2 (5% azolla) in their dietary ration (Table 3). These findings suggest that inclusion of azolla at 5% improves the growth performance, digestibility, and profitability, hence recommended for goat raisers to increase their income.

Table 6. Economics of raising Lactating Upgraded Goats Fed with Azolla-based Formulated Concentrate

DIETARY TREATMENT	Net income	ROI
Formulation 1 (0% azolla)	51.18^{c}	1.74^{c}
Formulation 2 (5% azolla)	788.85^{a}	18.80^{a}
Formulation 3 (10% azolla)	603.54^{b}	14.37^{b}
Formulation 4 (15% azolla)	202.59^{b}	6.47^{b}

Legend: Means within column with different superscripts are significantly different (P<0.05)

CONCLUSION

Generally, dietary supplementation of 5% Azolla in formulated concentrate for lactating F1 (50% Anglo-Nubian × 50% Native) upgraded goats significantly enhances overall performance. It improves final body weight, enhances the digestibility of feeds and legumes, and elevates milk quality, particularly in terms of higher milk fat, protein content, calcium, and vitamin A levels. Furthermore, the economic benefits are evident, as the increased milk yield and better body weight contribute to higher net income and return on investment, making this supplementation strategy both nutritionally and financially advantageous.

Recommendation

Supplementation pf 5% azolla in formulated concentrate serves as the optimal level because it provides a balanced protein and fiber ratio for improved digestion, minimizes antinutritional effects while enhancing nutrient utilization, supports rumen function and milk yield without disrupting dietary balance, and ensures better palatability and voluntary feed intake compared to formulation with 10% and 15% azolla. Thus, incorporating 5% Azolla in the diet of lactating upgraded goats presents a cost-effective feeding strategy that optimizes productivity while maintaining economic viability, hence recommended for goat raisers to increase their profit.

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REFERENCES

Ahirwar MK, Leela V 2012. Nutritive value and *in vitro* degradability of Azolla pinnata for ruminants. *Indian J. Vet. Sci.,* 89: 101–102.

Ahmed HA, Ganai AM, Beigh YA 2016. Performance of growing sheep on Azolla based diets. *Ind. J. Anim. Res.,* 50: 721–724. https://doi.org/10.18805/ijar.9642.

Anitha, K.C., Rajeshwari YB., Prasanna SB. & Shilpa, S.J. 2016. Nutritive Evaluation of Azolla as Livestock Feed. *Journal of Experimental Biology and Agricultural Sciences. 4*(6), 671-672. Retrieved from http://dx.doi.org/10.18006/2016.4.(Issue6).670.674.

Bacchu S., Meena, G. S., Meena, K.C., Meena, R.K., & Indoria D. 2017. Effect of a Wonder Herb Azolla on Buffaloes Milk Yield. *International Journal of Current Microbiology and Applied Sciences, 6*(11), pp. 1059-1066. Retrieved from http://www.ijcmas.com.

Cabaral, N.C. & Rieta, P.G.T. 2020. Growth, Blood Lipid and Meat Quality of Pekin Duck Fed with Different Level of Azolla Under Two Types of Production System. *Science Asia Review*. 1(1). 56-74. ISSN 2704-419X.

El Naggar, S., El-Mesery, H.S. 2022. Azolla pinnata as unconventional feeds for ruminant feeding. Bull Natl Res Cent 46, 66, 1-5. https://doi.org/10.1186/s42269-022-00752-w

Haenlein, G. F. W. 2004. Small Ruminant Research. *Science Direct, 51*(2), 155-163. Retrieved from www.sciencedirect.com/science/article/pii/s0921448803002724.

Huggins, D. 2007. Evaluation of azolla plant as an alternative stockfeed source. Animal Feed Resources Information System. INRAE CIRAD AFZ and FAO.

Kathirvelan, S. Banupriya, C. and M.R. Purushothaman. 2015. Alternate and Sustainable Feed for Livestock. *International Journal of Science, Environment and Technology*. Vol. 4, No 4, pp 1153 – 1157.

Leterme, P., A.M. Londoño, J.E. Muñoz, J. Suarez, C.A. Bedoya, W.E. Souffant, A. Buldgen. 2009. Nutritional value of aquatic ferns (Azolla filiculoides Lam. and Salvinia molesta Mitchell) in pigs. *Anim. Feed Sci. Technol.* 149(1-2): 135-148.

Murthy, T.N.K., M. Ashok, T. Thirumalesh, B.U. Umesh, & O.R. Nataraju. 2013. Effect of partial replacement of Azolla for concentrate supplement on lactating crossbred cows. Environment and Ecology. 31(2): 415-417.

Ndegwa, O. 2015. Diversify your livestock feeds with Azolla. Retrieved from http://ea-agribusiness.co.ug/diversify-yourlivestock-feeds-with-azolla/

Ndegwa, O. 2018, January 24. Use Azolla Organic Animal Feeds to Improve Quality, Quantity. *New Vision.* Retrieved from https://www.newvision.co.ug/new_vision/news/1330447/azolla-organic-animal-feeds-improve-quality-quantity

Parashuramulu, S., P.S. Swain, and Nagalakshmi, D. 2013. Protein fractionation and in vitro digestibility of Azolla in ruminants. *Online J. Anim. Feed Res.* Vol. 3, Issue 3. pp 129-132.

Pilai, P., Premalatha, S., Rajamony, S. 2015. Azolla: A Sustainable Feed for Livestock. Retrieved from http://www.agriculturesnetwork.org/magazines/global/small-animals-in focus/azolla-livestock-feed.

Rieta, P.G. & Cabaral, N.C. 2018. Acceptability, marketability and economics of organically grown broiler fed with azolla. *Asian Journal of Science and Technology.* 9(6). 8277-8282.

Roy D, Kumar V, Kumar M 2016. Effect of feeding *Azolla pinnata* on growth performance, feed intake, nutrient digestibility and blood bio-chemicals of Hariana heifers fed on roughage-based diet. *Ind. J. Dairy Sci.,* 69: 190–196.

Stergiadis, S., Stig Purup, N.P. Givens, I., & Lee, M.R.F. 2019. Comparative Nutrient Profiling of Retail Goat and Cow Milk. *Nutrients.* 11(10):2282. doi: 10.3390/nu11102282.

Tacio, T. D. 2012, January 6. Goat Raising Offers Income Opportunity for Farmers. *Gaia Discovery.* Retrieved from https://www.gaiadiscover.com/agriculture-industry/goat-raising-offers-income-opportunity-for-farmers.html.

Tran, T.L.N., A.F. Miranda, S. W. Abeynayake, and A. Mouradov. 2020. Differential Production of Phenolics, Lipids, Carbohydrates and Proteins in Stressed and Unstressed Aquatic Plants, Azolla filiculoides and Azolla pinnata. *Biology.* Vol. 9 Issue 342. pp 1-15.

Wolford, D. 2017. How to milk a goat: Step by Step Pictures. *Weed' em & Reap.* Retrieved from https://www.weedemandreap .com/how-to-milk-a-goat/.

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