Ciência Rural, Santa Maria, v.49:01, e20180515, 2019 http://dx.doi.org/10.1590/0103-8478cr20180515
ISSNe 1678-4596
ANIMAL PRODUCTION

Nutrient intake and apparent digestibility coefficient of lambs fed with coffee husk in replacement of oat hay

Fabíola Cristine de Almeida Rego[1] Laís Belan[2] Simone Fernanda Nedel Pertile[1*] Lisiane Dorneles de Lima[3] Agostinho Ludovico[4] Marilice Zundt[5] Flávio Guiselli Lopes[1] Petrônio Pinheiro Porto[6]

[1]Programa de Pós-graduação em Saúde e Produção Animal, Universidade Norte do Paraná (UNOPAR), 86702-765, Arapongas, PR, Brasil. E-mail: s.pertile@zootecnista.com.br.*Corresponding author.
[2]Universidade Norte do Paraná (UNOPAR), 86041-120, Londrina, PR, Brasil.
[3]Empresa Brasileira de Pesquisa Agropecuária (EMBRAPA), 62010-970, Sobral, CE, Brasil.
[4]Programa de Pós-graduação em Ciência e Tecnologia de Leite e Derivados, Universidade Norte do Paraná (UNOPAR), 86041-120, Londrina, PR, Brasil.
[5]Programa de Pós-graduação em Ciência Animal, Universidade do Oeste Paulista (UNOESTE), 19050-920, Presidente Prudente, SP, Brasil.
[6]Universidade Estadual do Norte do Paraná (UENP), 86360-000, Bandeirantes, PR, Brasil.

ABSTRACT: *This study aimed to evaluate the effects of replacing oat hay with coffee husk in the diet of lambs on the intake and apparent digestibility of dry matter (DM), organic matter (OM), crude protein (CP), ether extract (EE), non-fiber carbohydrate (NFC), neutral detergent fiber (NDF), and acid detergent fiber (ADF). The experimental design was 4×4 Latin square with four levels of replacement of oat hay with coffee husk (0, 7.5, 15, and 22.5%) with four individually housed Texel sheep. Intake and apparent digestibility coefficients were measured at four periods of 12 days. All orts and feces were collected, weighed, homogenized, and sampled. The use of coffee husk at up to 22.5% of the total DM in the diet of lambs improved the intake of nutrients. Except for NDF, no significant differences were observed for the apparent digestibility of other parameters (DM, OM, CP, EE, NFC, and the ADF). Coffee husk can be included at up to 22.5% of total dry matter in diets with 30% roughage and 70% concentrate, being a good alternative to reduce feed costs in lamb production.*
Key words: *byproduct, dry matter, fiber, protein, sheep.*

Ingestão e coeficiente de digestibilidade aparente de nutrientes em cordeiros alimentados com casca de café em substituição ao feno de aveia

RESUMO: *Objetivou-se avaliar os efeitos da substituição do feno de aveia pela casca de café na dieta de cordeiros no consumo e na digestibilidade aparente de matéria seca (DM), matéria orgânica (OM), proteína bruta (CP), extrato etéreo (EE), carboidratos não fibrosos (NFC), detergente neutro fibra (NDF) e fibra em detergente ácido (ADF). O delineamento experimental utilizado foi quadrado latino 4×4, com quatro níveis de substituição do feno de aveia por casca de café (0; 7,5%; 15%; 22,5%) e quatro ovinos Texel, os quais foram alojados individualmente. O consumo e os coeficientes de digestibilidade aparente foram mensurados em quatro períodos de 12 dias. Todas as sobras e fezes foram coletadas, pesadas, homogeneizadas e amostradas. O uso de casca de café na dieta de cordeiros com até 22,5% de DM melhorou o consumo dos nutrientes. Não foram observadas diferenças significativas para a digestibilidade aparente da DM, OM, CP, EE, NFC e ADF, exceto para o NDF. A casca de café pode ser incluída em até 22,5% da matéria seca total de dietas com 30% de volumoso e 70% de concentrado, sendo uma boa alternativa para reduzir os custos de alimentação na produção de cordeiros.*
Palavras-chave: *subprodutos, matéria seca, fibra, proteína, ovinos.*

Expenditure on food accounts for 70% of the total animal production costs. Consequently, several studies have investigated the use of by-products such as agroindustrial residues in feed, which may be a promising alternative for ruminant nutrition because of its availability and reduced cost (SOUZA et al., 2004).

Coffee husk, which is agroindustrial waste from the grain drying process, is one such alternative for use in ruminant feed. Brazil is the main global coffee producer, followed by Vietnam, Colombia, Indonesia, and Ethiopia, with Brazil and Vietnam together accounting for 49% of the total world production (ICO, 2018). For each ton of processed coffee, the same amount of waste is produced (DIAS et al., 2012), and some of this waste can be used for ruminant feed.

Nutrient intake and digestibility are very important factors influencing animal performance, and they may be either positively or negatively correlated with

Received 06.26.18 Approved 12.06.18 Returned by the author 01.16.19
CR-2018-0515.R1

each other, depending on diet quality, and are commonly referred to as associative effects (CRUZ et al., 2011).

In this study, we evaluated the effect of substituting oat hay with coffee husk in the diet of lambs on the intake and apparent digestibility of dry matter (DM), organic matter (OM), crude protein (CP), ether extract (EE), neutral detergent fiber (NDF), and acid detergent fiber (ADF).

The experiment was performed from May to December, 2013, at the University of North Paraná (UNOPAR) in Arapongas (23°S, 51°W, elevation 816m), Paraná, Brazil. This city presents a predominantly humid subtropical climate. The present study is in accordance with the ethical principles of animal experimentation of the Ethics Committee for Animal Use (CEA) of UNOPAR. The laboratory trials were performed in the Animal Nutrition Laboratory, Arapongas Campus (UNOPAR).

Four mature Texel sheep (mean body weight 15.3kg with a standard deviation of 3.48) were used, housed in individual, cemented, and partially covered bays equipped with troughs for food and water. Diets were formulated according to the nutritional requirements described by the NRC (2007) as isonitrogenous, and were composed of 300g/kg roughage (oat hay) and 700g/kg concentrate as DM (Table 1). The experimental design was 4×4 Latin square with four treatments and four replicates. The treatments consisted of four levels of substitution of oat hay with coffee husk: 0, 7.5, 15, and 22.5%.

Coffee husk was provided by the Agropecuária São Bento, located in Jataizinho (23°S, 50°W, elevation 346m), Paraná, and contained 946.9g/kg DM, 83.1g/kg ash, 79.6g/kg CP, 39.1g/kg EE, 665.0g/kg NDF, and 567.6g/kg ADF. The oat hay contained 920.9g/kg DM, 68.8g/kg ash, 109.6 CP, 11.4g/kg EE, 547g/kg NDF, and 311g/kg ADF.

Animals were fed twice daily at 08:00 and 17:00 h. Feed intake was monitored daily, and the food supply was set at 15% above the voluntary intake, adjusted according to the consumption during the previous day. Water was provided *ad libitum*. Representative samples of the total diet (concentrate and roughage) and the leftovers were collected in each experimental period for chemical analysis (Table 1). Samples were pre-dried in a forced-air oven at 55°C for 72h to determine the partial DM, milled in a Wiley mill with a 1-mm screen, and then stored for further analysis. The following variables were determined: DM, ash, OM, CP, EE, NDF, ADF, lignin (LIG), neutral detergent insoluble protein (NDIP), and acid detergent insoluble protein (ADIP), according to MIZUBUTI et al. (2009). Total digestible nutrients (TDN) were estimated in accordance with NRC (2001). Non-fiber carbohydrate (NFC) was estimated by NFC=100 − (NDF+CP+EE+ash).

Intake and apparent digestibility coefficients were measured within five experimental periods, with 62 days in total. The first period lasted for 14 days and was used for animal adaptation. The others periods comprised 12 days each, divided into diet adjustments (7 d) and digestibility trials (5 d). All orts and feces were collected from the 8th to the 12th day of each experimental period, and then weighed, homogenized, and sampled. Samples were dried at 55°C to constant weight, sieved (sieve with a 1-mm pore), and stored for further analysis. The DM, OM, NDF, ADF, NFC, CP, and EE apparent digestibility coefficients were determined by the difference between the dietary component consumed, and that excreted in feces.

Statistical analyses were carried out in the MIXED procedure of the statistical package SAS®, version 9.2 (SAS Institute Inc., Cary, NC). Results were considered significant at 5% probability.

The intake of CP, NDF, and ADF showed an increasing linear response as a function of the levels of coffee husk in diet (Table 2). The intake of DM and OM were similar for the different treatments studied, whereas nutrient intake increased, indicating that coffee husk did not negatively affect intake and animal performance, and that coffee husk can be used in ruminant feed. Moreover, the higher the level of coffee husk in the diet, the greater was the intake of nutrients.

A positive quadratic effect was observed for the variables EE and NFC intake (Table 2), and the highest mean values recorded were 21.07 and 450.53g, respectively, obtained for the diet with 7.5% coffee husk inclusion; a decrease in the intake of these nutrients was observed for the diets with 15 and 22.5% coffee husk in replacement of oat hay. Thus, inclusion of coffee husk at up to 7.5% of the total DM of the diet resulted in increased nutrient intake without affecting DM intake.

No significant differences in the apparent digestibility of DM, OM, CP, ADF, NFC, and EE were observed (Table 2); however, NDF responded in a linear and quadratic manner as a function of coffee husk levels. Although, we expected that DM and fiber would have lower digestibility, this was not reported with the increasing inclusion levels of coffee husk in the diets.

A possible explanation for the linear effect observed for NDF is that the inclusion of coffee husk in the diet had a positive effect on nutrient intake (Table 2); this shows that the inclusion did not limit

Table 1. Ingredient composition and chemical composition of diets containing different inclusion levels of coffee husk to replace oat hay.

----------Treatments*----------				
Ingredients (g/kg)	T 0	T 7.5	T 15	T 22.5
Oat hay	300.00	225.0	150.00	75.00
Coffee husk	0.00	75.00	150.00	225.00
Corn grain	476.5	467.9	459.4	450.8
Soybean meal	182.5	191.1	199.6	208.2
Mineral	23.0	23.0	23.0	23.0
Limestone	14.0	14.0	14.0	14.0
Salt	4.0	4.0	4.0	4.0
Total	100.00	100.00	100.00	100.00
----------Nutrients in DM**----------				
DM	929.0	934.8	938.4	932.1
Ash	80.8	42.9	79.3	67.7
CP	145.0	148.4	152.0	151.1
EE	23.5	25.0	19.8	19.6
NDF	176.2	241.8	285.9	329.5
ADF	809.6	136.7	176.7	191.2
Hemicellulose[1]	95.24	109.43	109.90	130.78
NFC	58.30	55.84	48.74	45.73
LIGNIN	2.1	3.4	3.5	3.7
CELLULOSE	15.7	33.0	50.5	63.0
NDIP	7.8	5.7	5.4	5.3
ADIP	0.10	0.10	0.20	0.30
TDN	693.1	691.4	584.0	571.1

*T0 – Control diet; T 7.5 – 7.5% coffee husk replacing oat hay; T 15 – 15% coffee husk replacing oat hay; T 22.5 – 22.5% coffee husk replacing oat hay.
** DM – dry matter; CP – crude protein; EE – ether extract; NDF – neutral detergent fiber; ADF – acid detergent fiber; NFC – non-fiber carbohydrate; NDIP – neutral detergent insoluble protein; ADIP – acid detergent insoluble protein; TDN – total digestible nutrients.
[1]Hemicellulose = NDF−NDA.

consumption by the animals; and therefore, did not reduce digestibility. For each unit of oat hay replaced by coffee husk, there were increases in NDF intake, ADF intake, and NDF digestibility of 3.08, 1.05, and 0.57%, respectively. The digestibility of the ADF was not altered with the substitution of hay with the coffee husk, possibly due to the higher levels of hemicellulose in the diets containing the coffee husk compared to the control diet, indicating that the NDF of the coffee husk has a fraction of hemicellulose with good digestibility.

According to VAN SOEST (1994), roughage-based diets are important for ruminants in confinement. Fiber helps to stimulate chewing and rumination, positively affecting digestibility since the digestibility of NDF improved with increased levels of coffee husk in the diet.

SALINA-RIOS et al. (2015) evaluated sheep diets supplemented with ensiled coffee pulp with 5% molasses (control, 8%, and 16% coffee pulp), and reported that food intake was not affected by the supplementation levels studied. Thus, up to 16% coffee pulp with 5% molasses can be added to lamb diets without affecting animal performance.

SOUZA et al. (2004) studied the effects on feed intake and apparent digestibility of replacing corn meal with different levels (0, 6.25, 12.5, 18.75, and 25% DM) of coffee husk in a concentrate diet for lambs, and observed a linear effect of coffee husk levels on EE intake, estimating a reduction of 0.528g per gram of husk added. In addition, no changes were observed in apparent digestibility for DM, OM, CP, and NDF.

BERNARDINO et al. (2009) reported no difference in EE digestibility coefficients for different coffee husk levels in diet, reporting an average of 79.1%, similar to that observed in this study (average of 83.7%).

Coffee husk can be included in diets of lambs at up to 7.5% of total DM in diets with 30% roughage and 70% concentrate, since it can improve

Table 2 – Nutrient intake and apparent digestibility coefficient of Texel lambs fed diets containing different levels of coffee husk in substitution to oat hay.

Nutrient intake (g) **	----------Treatments*				----------P-value----------			
	T 0	T 7.5	T 15	T 22.5	SEM	R^2	Linear	Quadratic
DM	732.44	830.26	836.07	813.61	4.39	0.96	0.44	0.13
DMIMW	80.79	87.87	89.92	87.91	0.432	0.92	0.42	0.28
OMI	673.21	796.20	769.95	760.16	3.826	0.97	0.55	0.06
OMIMW	74.25	84.25	82.81	82.12	0.376	0.93	0.52	0.10
CP	114.60	123.62	148.85	144.17	0.568	0.98	0.03	0.93
NDF	129.13	200.98	239.88	271.05	1.018	0.99	0.0001	0.14
ADF	99.07	113.53	148.35	154.80	0.844	0.97	0.002	0.68
NFC	412.22	450.53	364.57	328.52	2.303	0.97	0.03	0.02
EE	17.25	21.07	16.64	16.40	0.030	0.92	0.39	0.02
----------Nutrient digestibility----------								
DM	73.18	73.10	71.56	71.26	0.516	0.25	0.16	0.91
OM	74.43	75.16	72.12	72.39	0.513	0.27	0.08	0.81
CP	73.73	72.02	74.86	74.92	0.511	0.24	0.68	0.40
NDF	27.47	42.89	45.24	51.38	1.044	0.58	0.0001	0.03
ADF	38.63	36.07	41.35	41.66	1.114	0.43	0.42	0.44
NFC	92.01	92.38	91.63	91.80	0.157	0.46	0.44	0.58
EE	84.43	85.00	82.13	83.31	0.311	0.51	0.19	0.66

*T0: Control diet; T7.5: 7.5% coffee husk replacing oat hay; T15: 15% coffee husk replacing oat hay; T22.5: 22.5% coffee husk replacing oat hay; R^2= coefficient of determination; SEM: Standard error of the mean.
**DM – dry matter; DMIMW – dry matter intake as a function of metabolic weight; OM – organic matter; OMIMW – organic matter intake as a function of metabolic weight; CP – crude protein; NDF – neutral detergent fiber; ADF – acid detergent fiber; NFC – Non-fiber carbohydrate; EE – ether extract. Equations:
Intake: CP: $112.30+0.86x$; NDF: $130.39+3.08x$; ADF: $96.63+1.05x$; NFC: $420.93+2.94x-0.33x^2$; EE: $17.87+0.31x-0.02x^2$; Digestibility of NDF: $28.32+1.91x-0.04x^2$.

nutrient intake and NDF digestibility without affecting DM intake and the digestibility of other nutrients. Therefore, this by-product may be a good alternative to reduce feed costs in lamb production.

ACKNOWLEDGMENTS

The authors are grateful to the Coordenação de Aperfeiçoamento de Pessoal de Nível Superior (CAPES), for the post-doctoral scholarships of the third author.

COMMITTEE ON ETHICS AND BIOSAFETY

The experimental protocol was approved by the Ethical and Animal Welfare Committee of University North of Paraná (UNOPAR), under protocol number 012/13.

DECLARATION OF CONFLICTING INTERESTS

The authors declare no conflict of interest. The founding sponsors had no role in the design of the study; in the collection, analyses, or interpretation of data; in the writing of the manuscript, and in the decision to publish the results.

AUTHORS' CONTRIBUTIONS

The authors contributed equally to the manuscript.

REFERENCES

BERNARDINO, F.S. et al. Intake and digestibility of nutrients of elephantgrass silage with coffee hulls, by sheep. **Revista Brasileira de Saúde e Produção Animal**, v.2, p.460-469, 2009. Available from: <http://revistas.ufba.br/index.php/rbspa/article/view Article/1449>. Accessed: May 04, 2018.

CRUZ, B.C.C. et al. Performance, intake and digestibility of feedlot lambs receiving elephant grass silage with different proportions of dehydrated passion fruit peel. **Semina: Ciências Agrárias**, v.4, p.1595-1604, 2011. Available from: <http://www.uel.br/revistas/uel/index.php/semagrarias/article/view/4687/8973>. Accessed: Jun. 15, 2018, doi: 10.5433/1679-0359.2011v32n4p1595.

DIAS, JMCS et al. **Produção de briquetes e péletes a partir de resíduos agrícolas, agroindustrais e florestais**. Brasília: Embrapa

Agroenergia, 2012. 130p. Documentos, 13. Available from: <https://ainfo.cnptia.embrapa.br/digital/bitstream/ item/78690/1/ DOC-13.pdf>. Accessed: Jun. 25, 2018.

INTERNATIONAL COFFEE ORGANIZATION - ICO. **Historical Data on the Global Coffee Trade**, 2018. Total production by all exporting countries. Available from: <http://www.ico.org/prices/ po-production.pdf>. Accessed: Jun. 25, 2018.

MIZUBUTI I.Y., et al. 2009. **Métodos laboratoriais de avaliação de alimentos para animais**. Londrina: EDUEL, 2009. 228p.

NATIONAL RESEARCH COUNCIL -NRC. **Nutrient requirements of small ruminants**. Washington: National Academy Press, 2007. 362p.

NATIONAL RESEARCH COUNCIL -NRC. **Nutrient requirements of the dairy cattle.** 7.ed. Washington: National Academy Press, 2001. 363p.

SALINA-RIOS, T. et al. Productive perfomance and oxidative status of sheep fed diets supplemented with coffee pulp. **Small Ruminant Research**, v.123, p.17-31, 2015. Available from:<https://www.sciencedirect.com/science/article/pii/ S092144881400 2697>. Accessed: May. 23, 2018, doi: 10.1016/j. smallrumres.2014.09.008.

SOUZA, A.L. et al. Coffee husk in sheep diets: intake and digestibility. **Revista Brasileira de Zootecnia**, v.6, p.2170-2176, 2004. Available from: <http://www.scielo.br/pdf/rbz/ v33n6s2/23323.pdf>. Accessed: Apr. 23, 2018, doi: 10.1590/ S1516-35982004000800030.

VAN SOEST, P.J. **Nutritional ecology of the ruminant**. 2. ed. London: Constock Publishing Associates, 1994. 476p.