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Rice and Wheat stovers nutritional values comparison for Malian Sahelian zone dromedary

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Abstract

The dromedary, known as a desert and semi-desert areas animal, is beginning to adapt to southern Sahelian agro-pastoral zone, where crop residues (stovers) from rice and wheat constitute its important feed elements. However, nutritional values of these stovers are not available for the dromedary. To fill this gap, an experiment was carried out on 16 adult male dromedaries, aged around 7 years, to assess the quantity, the digestibility and the nutritional value of rice and wheat ingested stovers. Test dromedaries were divided into two batches of 8 heads each of which, batch 1 weighed on average 424.2 ± 5.1 kg and batch 2 426.3 ± 10.7 kg. Batch 1 was fed with rice, while batch 2 was on wheat stovers. The experiment lasted 28 days, including 15 days of adaptation, 7 days of feeding and 6 days of digestibility measurement. Total faeces collection method was used. Dry matter ingested was higher (p = 0.000) for rice stover than wheat one (4.5 kg against 2.4 kg). In contrast, the amount of water consumed per kg of dry matter ingested was higher (p = 0.000) for wheat stover (15.1 l) than for rice (7.6 l). Protein coefficients digestibility (49.9 ± 4.4%), cellulose (62.9 ± 4.0%) and energy (62.2 ± 2.8) were higher for rice than wheat (27.0 ± 2.4%; 46.5 ± 2.3% and 54.3 ± 1.6% respectively) stover. However, the metabolizable energy concentration was similar between stovers (7.6 ± 1.1 MJ / kg DM for rice and 7.2 ± 0.1 MJ / kg DM for wheat). The metabolizable energy per kgP$^{0.75}$ consumed per day was 0.081 MJ for rice and 0.077 MJ for wheat, stover. These results will improve dromedaries' rations preparation in their new agro-pastoral environments.

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Keywords: nutritional needs, chemical composition, ingestion, digestibility, agro-pastoral zone.

Introduction

Dromedary is an animal accustomed to the arid and semi-arid zones conditions (Ouologuem *et al.,* 2016, 2017; Faye *et al.,* 1997). However, in recent years, it has been observed in Mali their movement towards wetter areas dominated by agro-pastoralism and agriculture (Traoré *et al.,* 2019; Ouologuem *et al.,* 2016). Under these conditions, dromedary grazing habits have been adopted in favor of different types of feed in their new environments such as rice, wheat, millet and sorghum crop residues.

For example, from the stover / grain ratio of 0.63 (Nygaard *et al.,* 2012), stover production in the Office du Niger (ON) zone was estimated at 570,000 tons in 2010, out of a nationwide production of 1.5 million tons. Wheat production is starting to increase now according to Actualitix (2016) who reports a total estimated wheat production of 45,668 tons or around 50,000 tons of stover. In the Koro area, in Mopti region, the dromedary tends to replace draught cattle in agricultural work (Traoré *et al.,* 2019). In areas where rice and wheat are grown, dromedary readily indulges in crop residues. But the nutritional values of these by-products for this animal species are not available in these environments. Thus, to improve dromedary productivity in these agro-pastoral areas, the aim of the present study was to determine the dry matter amount, the nutrients digestibility and nutritional values of rice and wheat stovers for camels, in order to better insert them in production rations.

Materials and methods

There were 16 adult male dromedaries, divided into two batches of 8 heads each (Table 1). Batches were homogeneous by age and by weight.

Stovers distribution between the two batches was random. Experiment lasted 28 days, including 15 days of adaptation, 7 days of feeding and 6 days of digestibility measurement. During the feeding phase, stover quantities distributed were regularly increased in order to determine the maximum amount of ingestion. Digestibility was determined by the total fecal collection method using fecal collection bags.

Table 1: dromedary characteristics used in the study

Variables	Batch 1	Batch 2	Probability
Age (year)	7	7	
Race	Talabayatten	Talabayatten	
Live weight	424 (5,1)	426 (10,7)	0,87
Metabolic weight	93,5 (0,8)	93,8 (1,8)	0,88
Treatment	Rice stover	Wheat stover	

Numbers in brackets are standard error.

Bags were tied and untied twice a day, in the morning between 7 and 8 a.m. and in the afternoon between 5 and 6 p.m on each dromedary. After each bag detachment from each animal, the amount of faeces was weighed, and then a 10% sample was taken and kept cold per day. In addition, the quantities of stover distributed and refused as well as the quantity of water given and refused were measured per animal. At the end of 6 days of collection, faeces, donated and refused stovers were grouped by animal and an average sample was taken for laboratory analyzes. Variables determined were dry matter, organic matter, total protein, crude fiber, fat, crude energy and non-nitrogenous extract by calculation. All determinations were made following (Petouhova *et al.,* 1981; Ezdakova and Romanov, 1981) methods.

The dry matter was determined in two steps: 1) from the primary humidity (Hp) by drying at 65 °C to constant weight to obtain the primary or initial dry matter (MSp), then 2) the residual humidity (Hr) at 105 °C up to constant weight. Formulas used were as follows:

Primary humidity (Hp) = ((m1 - m2) / m1) * 100, where;
m1 - sample weight before drying;
m2 - sample weight after drying to 65%;
The percentage of primary dry matter (MSp) = 100 - Hp;
Residual moisture was calculated by the formula:
Hr = (m3 - m4) * MSp) / 100;
Where, Hr - amount of residual water in percentage;
m3 - sample weight before drying at 105 ° C;
m4 - sample weight after drying at 105 ° C;
MSp -% primary dry matter obtained from drying at 65 °C;
The absolute dry matter (MSa) of samples was calculated by the formula:
MSa = 100 - (Hp + Hr), where;
Hp -% primary humidity;
RH -% residual humidity.
Then organic matter (OM), crude protein (PB), cellulose (CB), fat (MG) and energy (EB), the non-nitrogenous extract (ENA) in samples given and refused and in faeces were calculated. These variables were expressed from absolute matter.
From analyses results, the amount of dry matter ingested (MSI) per animal was calculated using the following formula:
MSI = (Qd - Qr), where:
Qd - amount of dry matter given to each animal;
Qr - amount of dry matter refused (non ingested) per animal.
Subsequently, the MSI was expressed in grams per kg of bodyweight, in kg per 100 kg of bodyweight and in g per kilogram of metabolic weight ($P^{0.75}$).
Then, digestibility coefficients of the different nutrients (x) were determined from analyzed results following the general formula:
D (x) = ((xi - xf) / xi) * 100, where; D (x) - digestibility coefficient of the nutrient, in percentage; xi - amount of nutrient ingested, in g; xf - amount of the nutrient in excreted faeces, in g.
From obtained digestibility coefficients, digestible protein (MAD), digestible energy (DE), metabolizable energy (ME) and net energy (forage unit) concentrations were calculated by the following formulas:
MAD (g / kg DM) = (MAT * dMAT) / 100
MAT - amount of total nitrogenous matter (crude protein) in the dry matter ingested, in g
dMAT - coefficient of digestibility of MAT; Metabolizable energy was obtained using Schiemann formula reported by Rivière (1978):
EM = 4.17MAD + 7.46MGD + 3.26CBD + 3.53ENAD, where:
ME - metabolizable energy in kcal / kg;
MAD - digestible nitrogenous matter per kg of DM;

MGD - digestible fat per kg of DM;
CBD - Crude digestible fiber per kg DM;
ENAD - digestible non-nitrogenous extract per kg of DM
Then the ME was converted to mega joules (MJ) using the formula:
ME (MJ / kg DM) = (ME (kcal) * 4.184) / 1000
The net energy (forage unit) was calculated by the Brerheim formula cited by Jarrige (1978):
UF / kg MS = (2.36 * MOD - 1.2 * MOND) / 1650, where
MOD - digestible organic matter in g per kg DM
MOND - non-digestible organic matter in g per kg DM.
1650 - energy content in one kg of medium quality barley.
Data were analyzed using descriptive statistics and analysis of variance methods (completely randomized design) considering the stover nature as a factor using Minitab software, version 18.

Results

Chemical composition of wheat and rice straws

The two stovers are all very low in crude protein (Table 2). However, rice stover is almost twice as rich in crude protein as wheat. On the other hand, wheat straw is richer in organic matter, cellulose and energy than that of rice one. The two types of stovers were comparable in terms of dry matter and fat.

Table 2: chemical composition of rice and wheat stovers used during the study.

Stover types	Dry matter, %	Organic matter, %	Ether Extract, %	Crude proteins, %	Crude cellulose, %	Non-nitrogenous extract, %	Crude energy, MJ/kg
Rice	93,6 (0,7)	84,5 (0,3)	1,7 (0,1)	6,5 (0,1)	33,6 (0,6)	42,6 (0,5)	14,8 (0,1)
Wheat	92,2 (0,4)	92,2 (0,6)	1,5 (0,1)	3,6 (0,2)	38,3 (0,2)	48,8 (0,5)	16,0 (0,1)
Probability	0,11	0,00	0,25	0,00	0,00	0,00	0,00

Numbers in brackets indicate standard error

Amount of stover dry matter intentionally ingested

The MSI per day was higher in dromedaries fed with rice stover compared to those fed with wheat stover regardless of the mode of expression (Table 3). However, the amount of water consumed was similar between the two batches. But, expressed per kg of dry matter ingested, the quantity of consumed water consumed significantly higher in the batch of camels that received wheat stover than rice one.

Table 3: dromedaries' rice and wheat stover quantities of dry matter ingested during the study

Variable	Rice stover	Wheat stover	Probability
Dry matter/animal/day, kg	4,5 (0,05)	2,4 (0,10)	0,00
Dry matter/100 kg de PV, kg	1,1 (0,02)	0,6 (0,01)	0,00
Dry matter/kg de PV, g	10,6 (0,02)	5,6 (0,01)	0,00
Dry matter/kg de $P^{0,75}$, g	4,8 (0,10)	2,6 (0,05)	0,00
Quantity of water consumed/animal/day, l	34,1 (4,10)	36,9 (4,10)	0,18
Quantity of water consumed /kg of DMI, l	7,6 (0,30)	15,1 (0,50)	0,00

Numbers in brackets indicate standard error.

Digestibility

No statistical difference was observed among digestibility coefficients of dry matter, organic matter, fat and non-nitrogenous extract between the two types of stover (Table 4). In contrast, the digestibility coefficients of nitrogenous matter, cellulose and energy were higher for rice, compared to wheat, stover.

Table 4: dromedary digestibility coefficients (%) of rice and wheat stover nutrients

Stover	Dry matter	Organic matter	Nitrogenous matter	Cellulose	Ether extract	Non-nitrogenous extract, %	Energy
Rice	56,3 (3,1)	60,2 (3,0)	49,9 (4,4)	62,9 (4,0)	76,3 (7,1)	58,7 (2,0)	62,2 (2,8)
Wheat	48,2 (2,4)	52,9 (2,2)	27,0 (2,4)	46,5 (2,3)	80,1 (2,0)	58,4 (2,6)	54,3 (1,6)
Probability	0,06	0,07	0,00	0,00	0,62	0,92	0,03

Numbers in brackets indicate standard error

Nutritional value

The digestible nitrogen content was higher in rice, compared to wheat, stover (Table 5). In contrast, the metabolizable energy and net energy concentrations were comparable between the two stovers.

Table 5: nutritional values of rice and wheat stovers for dromedaries.

Variable	Rice stover	Wheat stover	Probability
Nitrogenous digestible matter, g/kg DM	32,9 (9,0)	9,9 (3,7)	0,00
Net Energy, UF/kg DM	0,4 (0,2)	0,33 (0,1)	0,56
Metabolizable energy, MJ/kg DM	7,6 (1,1)	7,2 (0,1)	0,46

Numbers in brackets indicate standard error

Amount of nutrients ingested by dromedaries

The amounts of MAD, metabolizable energy and net energy in forage unit ingested per day are higher in the batch of animals that received rice stover than wheat one (Table 6). However, the amounts of metabolizable energy per kg of metabolic weight are similar between the two stovers.

Table.6: quantity of digestible nitrogenous matter and ingested energy by dromedaries

Variable	Rice stover	Wheat stover	Probability
Digestible nitrogenous dry matter, g/day	148 (15,0)	24,5 (3,5)	0,00
Net Energy, UF /day	1,7 (0,3)	0,82 (0,1)	0,01
Metabolizable energy, MJ/day	34,1 (2,0)	17,8 (1,2)	0,00
Metabolizable Energy, MJ/P^{0,75}	0,08 (0,01)	0,08 (0,01)	0,43

Numbers in brackets indicate standard error.

Discussion

Stovers chemical composition

Dry matter content (DMC) of rice stover was 93.6% and that of wheat was 92.2%. Rice stover DMC is higher than the 87.43% of Abdel-Wahed (2014). The percentage of wheat stover dry matter is comparable to 92.2% of Karabulut et al. (2006), but is higher than the 89.09% of Ciansi et al. (2004).

The organic matter (OM) was 84.5% for rice stover and 92.2% for wheat one. The percentage of rice stover OM from this study is higher than the 78.32% of Abdel-Wahed (2014). For wheat stover, the present result is slightly higher than the 90.8% of Karabulut et al. (2006) and 91.41% of Ciansi et al. (2004). Das and Singh (1999) obtained results that ranged from 86.9% to 87.77%, which are lower than those of the present study. The rate of crud protein (CP) in rice stover was 6.5% ±0.1 and 3.6 ±0.2% for wheat. The CP rate of the present rice stover study is higher than the 4.55% of (Abdel-Wahed, 2014; Farid et al., 2010) and the 3.5% in rice stover reported by FAO (1997). Sarnklong et al. (2010) observed variations in nitrogen in rice stover from 0.88% to 1.04% or 5.5% to 6.6% MAT, which is comparable to the present results.

Wheat stover CP level from this study is comparable to 3.56% of Ciansi et al. (2004), but slightly lower than the 3.9% reported by Abdouli et al. (1988) and the 4, 1% of Karabulut et al. (2006). Crude protein levels of 3.23% to 3.64% were obtained by Das and Singh (1999). The MAT rate in this study is higher than the 2.9% reported (Joseah, 2019). The crude fiber content was 33.6% in rice stover and 38.3% in wheat one. Rice stover rate from current study is higher than the 28.86% of (Farid et al., 2010; Abdel-Wahed, 2014). Sarnklong et al. (2010) observed an average of 33.5% (31.96 - 35.81%) in rice stover, which is comparable to that of the current study. Wheat stover crude fiver content is comparable to 38.67 of Das and Singh (1999), but is lower than 44.68% of Ciansi et al. (2004) and 41.8% of Karabulut et al. (2006). Fat content was 1.7% for rice stover and 1.5% for wheat. The percentage of fat in rice stover is less than the 2.52% (Farid et al., 2010; Abdel-Wahed, 2014). Wheat stover crude fiber is lower than 2.3% of Karabulut et al. (2006), but higher than 1.02% of Ciansi et al. (2004) and is close to 1.31 - 1.67% of Das and Singh (1999). The non-nitrogenous extract (ENA) of the current study was 42.6% for rice stover and 48.8% for wheat one. The ENA of rice stover is comparable to 42.39% of Farid et al. (2010) and 42.36% of Abdel-Wahed (2014), but that of wheat stover is higher than 42.17 of Ciansi et al. (2004).

Amount of dry matter ingested

The amount of dry matter ingested from rice stover was 4.2 kg and 2.4 kg for wheat. Expressed in animal weight, amounts of ingested stover was higher for rice than wheat one. This large difference could be explained by the absence of leaves, but also the low level of protein in the wheat stover used unlike that of rice. Indeed, Sarnklong et al. (2010) reported that rice stover has a higher percentage of leaves (60%) than most cultivated cereals such as wheat (20 - 41%). The amount of dry matter ingested from rice stover (4.8 g / kgP0.75) is less than the 16.11 g / kg$P^{0.75}$ of Farid et al. (2010). Quantity of ingested wheat stover is less than the 3774 ± 125 g (32 g / $P^{0.75}$) reported by Ciansi et al. (2004). On the other hand, the present result is comparable to 0.65 g / 100 bodyweight or 32 g / $P^{0.75}$ in lactating females from Hashi and Kamoun (1995). This finding allows us to suggest other studies with different types of wheat stover to understand dromedaries' capacity to ingest this coarse feed. In addition, lack of data on rice and wheat stovers ingestion by dromedaries, especially in Africa, calls for more studies to better integrate dromedary into agro-pastoral systems. The total quantity of water consumed was 34.1 ± 4.1 for rice stover batch and 36.9 ± 4.1 l for wheat one. The amount of water taken per kg of MSI was 7.6 ± 0.3 l for rice and 15.1 ± 0.5 for wheat, stover. This difference could be explained by higher wheat stover cellulose content compared to rice stover. These values are higher than those reported by Ciansi et al. (2004) which was 2.5 l / kg MSI for wheat stover for a total consumption of 14 l per day.

Nutrient digestibility coefficients

Dry matter digestibility coefficients were 56.3 ± 3.1% for rice and 48.2 ± 2.4% for wheat stover. These rates can be considered average, because about half of the dry matter is ingested. Wheat stover digestibility rate is slightly higher than the 44.81 ± 1.72% of Ciansi et al. (2004). Moreover, these authors reported digestibility rates of 48.02% for organic matter, - 0.90 ± 7.41% for proteins, 57.33 ± 2.06% for crude fiber and 46.57 ± 2.26% for energy. These rates, except that of cellulose, are lower than those found in the present study. Heller et al. (1986) reported that one of the factors of fibrous forage with dromedary is explained by a longer retention period of feed particles in the digestive tract, which gives an advantage to this species on domestic ruminants.

Stover nutritional values

Rice stover nitrogenous digestible matter (MAD) concentration was 32.9 ± 9.0 g / kg DM and 9.9 ± 3.7 g / kg DM for wheat stover. The metabolizable energy was 7.7 ± 1.1 MJ / kg DM for rice stover and 7.2 ± 0.1 MJ / kg DM for wheat. The net energy in forage unit was 0.37 for rice and 0.33 for wheat, stover. These concentrations show that dromedary can derive maximum benefit from poor forages. Indeed, according to Le Houerou (1980), the digestible protein content becomes zero in ruminants when the crude protein content drops to 3.8% or less. Nonetheless dromedary was able to extract 10 g of MAD from forage very low in protein (3.6%). However, the negative digestibility coefficient of proteins (- 0.90%) for a forage containing 3.56% protein reported by Ciansi et al. (2004) indicates that dromedary may also not value poor forages in certain circumstances. The metabolizable energy content of wheat stover reported here is slightly higher than the 6.9 MJ / kg DM of Ciansi et al. (2004).

Nutritional needs coverage

MAD amount consumed per day was 148 ± 15 g for rice and 24.5 ± 3.5 g for wheat, stover. Average dromedaries weight was 424 ± 5 kg for rice and 426 ± 10.5 kg for wheat, stover.

Amount of metabolizable energy ingested per day was 34.1 ± 2.0 MJ for rice and 17.8 ± 1.2 MJ for wheat, stover. Values expressed per kg of metabolic weight were 0.081 MJ for rice and 0.077 MJ for wheat, stover. In reference to Al Jassim et al. (2019) recommendations, the amount of energy ingested from the present rice stover makes it possible to cover the maintenance needs of adult camels. Indeed Al Jassim et al. (2019), recommend between 30.9 MJ for a 400 kg live dromedary weight and 33.7 MJ / day for one weighing 450 kg. However, wheat stover used in the present study does not cover 450 kg camels maintenance needs. According to Al Jassin (1998), the metabolizable energy requirement for camel maintenance is 0.314 MJ / $P^{0.75}$ / per day). Wardeh (2004) reported that maintenance requirement for dry matter and metabolizable energy is 2.5% live weight for dry matter preferably containing 10.88 ME / kg DM, but not less than 8.79 MJ / kg DM or 0.435 MJ / kg $P^{0.75}$. On the other hand, Guerouali and Wardeh (1998) reported a maintenance requirement of 296 kJ / kg $P^{0.75}$, or 0.296 MJ / kg $P^{0.75}$. Regarding protein, Wardeh (2004) recommended 2.70 g of digestible protein / kg $P^{0.75}$. The values advocated by Al Jassim (1998) and Wardeh (2004) are respectively about 3.8 times and 5.4 times higher than the energy concentration in the dry matter ingested from the present rice stover study.

Conclusion

Nutritional value knowledge of wheat and rice stovers makes it possible to consider the introduction of these two crop residues in camels feed wherever these crops are produced, which will facilitate dromedary husbandry integration in agricultural system. However, it appears that rice and wheat stovers alone are not sufficient to meet dromedary maintenance needs in protein and energy. Further studies are still necessary on one hand on different stover types and on types and levels of concentrated feed to be incorporated on the other hand into the rations for dromedary better feeding in its new agro-pastoral environments.

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