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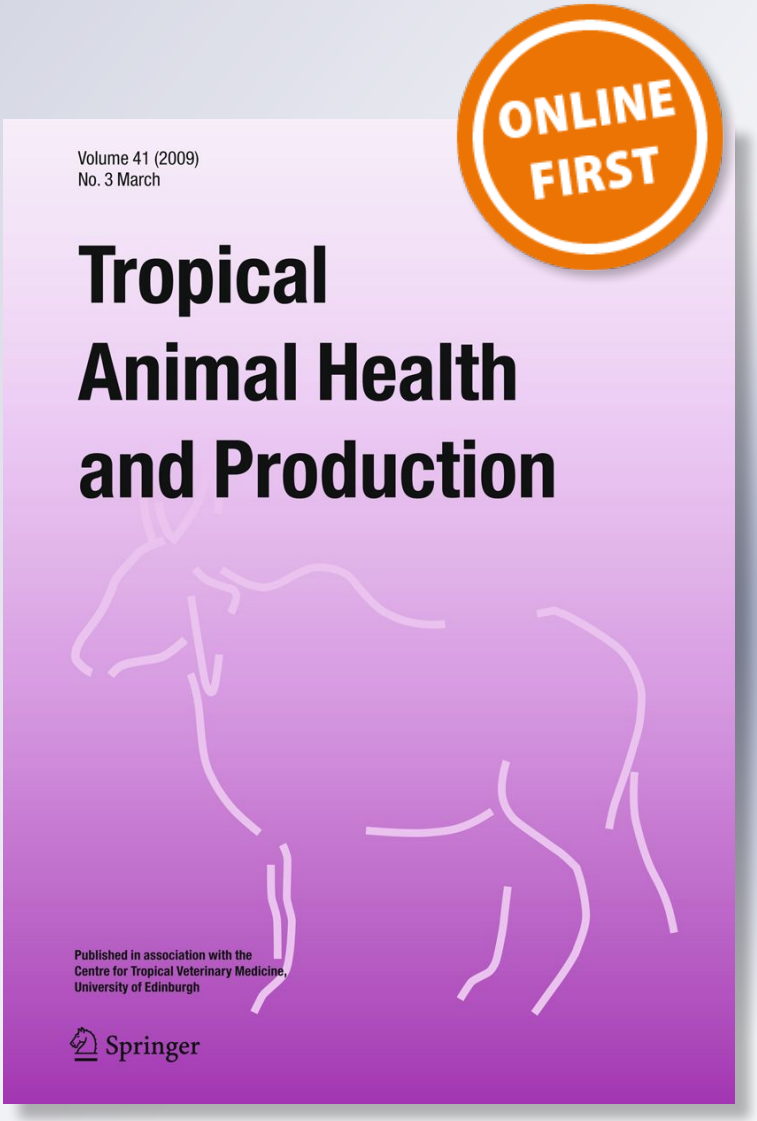

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REGULAR ARTICLES

Chemical composition, digestibility, and voluntary feed intake of mango residues by sheep

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Abstract The chemical composition, digestibility, and voluntary feed intake by sheep of mango by-products were studied in an experiment with five dietary treatments consisting of mango peels and seed kernels, offered individually or together with urea block and a control. The mango residues were offered with rice straw and the control diet was straw only. Five groups of five male sheep of Djallonké type, 12–18 months old and weighing on average 18.6 kg were allocated randomly to the diets to assess the voluntary feed intake. Apparent digestibility of the same diets was measured using four sheep per diet. The mango residues were low in crude protein, 67 and 70 g/kg dry matter for the peels and the seed kernels, respectively. The content of neutral detergent fiber varied from 306 to 388 g/kg dry matter (DM) for the kernel and the peels, respectively. The kernel had relatively high level of fat (105 g/kg DM) and tannins (29 and 40 g/kg DM of hydrolysable and total tannins, respectively). The highest intake was observed with the diet containing both residues and urea block (741 g/day). The intake of kernels was lower in all diets when offered with the peels than when offered with rice straw alone. Apparent digestibility of the diets containing mango residues was 0.60–0.65. The peels and kernels had high digestibility coefficients (0.74 and 0.70, respectively). Based on the results above, it can be concluded that it would be interesting to test the residues in a growth experiment.

Keywords Mango peels · Mango seed kernels · Chemical composition · Voluntary feed intake · Digestibility

Introduction

The main constraint of livestock production in Burkina Faso remains the insufficiencies in quantity and quality of feed resources. Natural pastures, which constitute the basis of feeding, are decreasing in productivity due to the combined effects of dryness and the increase in cropland area. Agro industrial by-products such as cottonseed, cottonseed cake, and molasses, that are used for intensive animal production as well as for productive animals in extensive production systems, are less accessible due to the high cost, and the scarcity due to various uses, e.g., export to other countries. Thus, there is a need to find alternative feed resources.

Mango is one of the most cultivated fruit trees in Burkina Faso, with a production estimated at 71,000 tons in 2008 (Bambio 2009). There are about 70 units of mango processing, with a capacity of up to 1,000 tons of mainly dried products but also juice and jam. One larger factory transformed 5,000 tons of mangoes to juice in 2009 according to BACGF (2010).

The mangoes are peeled and sliced by hand, and the slices are then dried while the peel and seed are waste products representing 50–65 % of the mango fresh weight according to the variety of mango. The wastes are occasionally consumed by animals, but most of it is just scattered and constitutes a problem for the environment.

The peels and seed kernels are poor in protein; a mean content of crude protein (CP) of 6 % has been reported by Elegbede et al. (1996). The peels are rich in fiber, while the seed kernel is rich in starch and lipids, which suggest high energy content. Sruamsiri and Silman (2009) reported 3.83 and 4.07 kcal/g dry matter (DM) (~16 and 17 MJ/kg DM) of gross energy content, respectively, in the peels and the seed kernel.

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Saiyed et al. (2003) included up to 25 % of mango seed kernels in a concentrate for goats. This allowed a significant reduction in feed costs, without any negative effect on animal performance. Odunsi (2005) reported an increased weight gain of broilers offered a diet containing up to 100 g/kg of mango seed kernels and soybean meal. It is also possible to make silage with mango peels mixed with dried forages for feeding animals (Sruamsiri and Silman 2009).

This study aimed to estimate the chemical composition and digestibility of mango peels and seed kernels and to determine the voluntary feed intake by sheep of these by-products. The hypothesis was that the digestibility and intake would be high enough to merit further research into the use of mango residues.

Material and methods

Study area

The study was undertaken in the Sudanian zone of Burkina Faso, in the provinces of Houet, Comoé, and Kenedougou. This area is the most humid part of the country, with a mean annual rainfall of 1,000–1,200 mm. The rainy season lasts 5 months from May to September (Fontes and Guinko 1995). These provinces are considered the orchard of the country with regard to the importance of fruit tree plantations (mango, citrus, and cashew nut).

The mango residues (peels and seeds) were collected from the mango processing unit of the association Wouol at Beregadougou (Comoé province). The trials with animals were conducted at the research station at Bobo-Dioulasso (Houet province).

Preparation and analysis of the experimental feeds

The peels were dried with a gas drier (the same equipment as used for drying mango pulp), then stored in plastic bags. The seeds were decorticated to extract the kernels, and the kernels were pound and dried for use in 3 days maximum since the kernels were quickly attacked by mold. The rice straw was collected from the rice fields and was used as the roughage source since it is available and cheap in the dry season in the area.

Random samples of mango peels, seed kernels, and rice straw were taken for chemical analysis. They were ground in a Wiley mill through a 1-mm screen and were analyzed for DM, ash, CP and neutral detergent fiber (aNDF), and ether extract (EE). DM (ID 967.03), CP (ID 984.13), and ash (ID 942.05) were analyzed according to the standard methods of AOAC (1990). aNDF was determined by the methods of Van Soest et al. (1991) using sodium sulfite and amylase and was expressed with residual ash.

The content of tannins (hydrolysable and total) was determined according to CEE method by spectrophotometer at λ=525 nm (Journal officiel des CEE, 1984). The urea block was made with locally available products (40 % millet bran, 20 % salt, 15 % urea, 15 % cement, 10 % bone powder, and water). The chemical composition was 939 g/kg DM, 475 g/kg DM of ash and 417 g/kg DM of CP.

Study of voluntary feed intake

Male sheep of "Djallonké" type, 12–18 months of age and weighing on average 18.6 kg (SD=2.6) were used for measuring the voluntary feed intake and in vivo digestibility. They were housed in a sheephouse and tied inside the pens in the intake trial to allow individual feeding and watering. The sheep were vaccinated against pasteurellosis using pastovin (1 ml/animal) and trypanosomosis using survidim. They received also prophylactic treatment against gastrointestinal parasites using albendazole tablets (1/2 tablet/animal) and antibiotic oxytetracycline (1 ml) before the commencement of the experiment.

A completely randomized design was used to allocate 25 animals to five groups with five animals in each group. Five treatments consisting of five diets were allocated randomly to the groups. The diets were: mango peels (MP), mango seed kernels (MSK), mango peels+mango seed kernels (MP+MSK), mango peels+mango seed kernels+urea block (MP+MSK+UB), and negative control group offered only rice straw (Control).

The mango by-products were fed with rice straw and all feeds were offered ad libitum to allow free selection. At the beginning of the experimental period, a level of 4 % of body weight (BW) was offered for the whole feed, and then the amount offered was increased to 130 % of the amount consumed the previous day on an individual basis for all feeds. The urea block was used in the MP + MSK + UB diet to compensate for the low CP content of mango residues and test its effect. The other groups had free access to an industrial mineral block (KNZ brand, 63 % NaCl, 9 % Ca, 11 % P, 1.26 %Mg, 1 % Fe, 0.15 % Cu, 0.12 % Mn, 0.05 % I, and 0.01 % Co). All animals had free access to water.

The feeds were offered at 8 h in the morning and at 17 h in the afternoon, and the refusals were removed and weighed each time. The experiment started with an adaptation period of 2 weeks, followed by a measurement period of voluntary intake for 1 week. The animals were weighed at the beginning and the end of the experiment.

Digestibility study

At the end of the intake trial, four animals per diet were randomly selected to continue a digestibility experiment with the same feeds. Digestibility cages equipped with a

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feeding trough and water container were used, and the animals wore feces collection bags to prevent losses of feces. The sheep were randomly allocated to the digestibility cages and adapted to the cages for 3 days, followed by 7 days of measurement. They were fed at maintenance level with the same amount of mango residues in each group (500 g/day). The rice straw was added to the mango residues at a level of 40–50 % of the diet, based on observation from the intake trial. The animals had free access to water and mineral blocks or UB. The feed refusals were weighed, as well as the feces, which were removed every morning. Fecal outputs were mixed on a weekly basis, and representative samples as well as feed samples were taken for chemical analysis.

Statistical analysis

The data were analyzed using the general linear model of MINITAB software version 14 (MINITAB 2002). The treatment means which showed significant difference at the probability level of $P<0.05$ were compared using Tukey's pairwise comparison procedures.

The data from the voluntary feed intake and digestibility trials were submitted to a one-way analysis of variance according to the model: $Y=\mu+\alpha_i+e_{ij}$ with Y as the dependent variable, μ the general mean, α_i the main effect of the diet, and e_{ij} as the residual.

Results

Chemical composition

The chemical composition of the mango residues is presented in Table 1. The CP content of the mango residues was relatively low (67.0 and 70.5 g/kg DM, respectively, for the peels and the seed kernels) but high compared to the value of rice straw (42.5 g/kg DM). The content of NDF was low in mango residues compared to rice straw. The seed kernels contained a moderate level of tannin (40 g/kg DM of total tannins and 29 g/kg DM of hydrolysable tannins) and a high level of EE (104 g/kg DM).

Table 1 Chemical composition of mango residues

	Dried peels	Seed kernels	Rice straw
Dry matter (g/kg)	922	927	930
Crude protein	67.0	70.5	42.5
NDF	388	306	617
Ash	60	42	129
Ether extract	47	105	11
Hydrolysable tannins	6.2	29	–
Total tannins	–	40	–

Study of voluntary feed intake

There was no significant difference in the total DM intake of the three diets containing only mango by-products (Table 2), but the animals receiving the diet containing urea block, had higher intake, significantly different only from the control.

The intake of peel in the diet MP+MSK+UB was significantly higher than the intake in the diet MP+MSK (364 g) and similar to the intake of diet with only MP. Overall, the peels consumed accounted for 60–64 % of the diets containing peels.

The intake of seed kernels was higher in the diet MSK, where this ingredient was fed with rice straw only. In the presence of peels, very small amounts of kernel was consumed by the sheep, 7 and 8 % of the total intake of the diets MP+MSK and MP+MSK+UB, respectively, against 43 % for the diet MSK.

The intakes of rice straw were similar in all diets containing mango by-products and significantly lower than the control diet (527 g). More crude protein from the mango by-products was consumed with the diet containing urea block (40.2 g/day), and the lowest CP intake was of the control diet (22.4 g/day). The crude protein intake of the other diets was similar.

The feed intake in % of BW was significantly lower when the animals fed only rice straw (Control) or only MSK. There were no significant changes in BW during the experiment.

Digestibility study

Table 3 presents the DM digestibility of the diets and their components (peels, kernels, and rice straw). The intake of peels and kernels in the digestibility trial followed the same trend as in the intake trial. The total intake was similar for all diets, and there was no difference in the digestibility coefficients among the diets with mango residues, but the control diet had a significantly lower digestibility coefficient. The digestibility of mango peels and seed kernels calculated by difference were high, 740 and 700 g/kg DM, respectively, and significantly different from that of rice straw.

Discussion

Chemical composition

Many authors have reported a low CP content in mango peels and mango seed kernels. Odunsi (2005) and Elegbede

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Table 2 Voluntary feed intake (g DM/day) of diets with mango peels and seed kernels

	MP	MSK	MP + MSK	MP + MSK + UB	Control	SE	*P*
MP	407ab		364a	476b	–	21	0.4
MSK		244a	45b	62b	–	1	0.00
Rice straw	262a	323a	208a	204a	527b	38	0.00
Total intake	669ab	567ab	617ab	741a	527b	38	NS
CP intake g/day	36.5 ac	31.7a	36.4 ac	40.2[a]c	22.4b	1.5	0.00
Intake, % of BW	3.2ab	2.7a	3.6b	4.0b	2.5a	0.2	0.00
Weight change (kg)	0.32	0.18	0.58	0.64	0.10	–	–

Means in the same row with different letters after the values are significantly different ($P<0.05$)

MP mango peels, *MSK* mango seed kernels, *UB* urea block

[a] This value is without UB intake

et al. (1996) noted a mean value of 6 % of DM in the kernels. Ojokoh (2007) reported 8.64 % of CP in DM in mango seed kernels. The content of CP in DM in the present research is intermediate compared with these two studies. The protein content in peels in this study (64 g/kg DM) is high compared to the value (4.68 %) obtained by Sruamsiri and Silman (2009). The protein content in all the mango residues is close to the range of 7 % required for the maintenance requirement of the rumen microorganisms (Norton 1998). These residues are therefore better than straws which seldom contain more than 40 g CP/kg DM. The fat content of the kernel is lower than the mean obtained by Elegbede et al. (1996), Abdalla et al. (2007), and Moharram and Moustafa (1982). The fiber content of mango residues seem to vary to a large extent as reported in the literature. Sruamsiri and Silman (2009) found 25 % of NDF in the peels, which is low compared to our result. The concentration of tannin in the kernel is lower than the value (6.37 %) reported by Arogba (2000). The difference observed in chemical composition between our results and other studies could be explained by the varieties of mango used and/or the methods of extraction of the residues especially the peels.

Intake and digestibility

Studies on voluntary feed intake and digestibility of peels and seed kernels of mango are rare in the literature, rendering difficult the comparison of the results with other work. The intake of mango peels was high despite the low protein content. The low intake of the kernel can be explained by the tannin concentration which is relatively high (40 g/kg DM of total tannins) as the protein content was similar for both residues. The tannins known as anti-nutritional factors are shown to form a complex with protein and then influencing negatively the voluntary feed intake (Kaitho et al. 1996). In addition to the tannins, mango seed kernels could contain other phenolic compounds such as phytate, oxalate, saponin, and alkaloids (Arogba 2000; Abdalla et al. 2007; Fowomola 2010). These substances lowered the feed intake due to their astringent properties and could also indirectly reduce the digestibility of the feed (Hanley et al. 1992). The high intake of the diet containing urea block could be due to the increased level of nitrogen, which improves the energy/protein ratio. Especially, the intake of peels increased significantly with the inclusion of a nitrogen source in the diet. The same observation was made by Odunsi (2005), who found that adding soybean, as a protein

Table 3 Digestibility of mango peels, kernels, and the diets

Diets	MP	MSK	MP+MSK	MP+MSK+UB	Control	SE	*P*
Intake (g/day)							
MP	177[a]		233[ab]	268[b]	–	21	0.04
MSK	–	245[a]	43[b]	57[b]	–	10	0.00
Rice straw	159[a]	235[a]	122[a]	125[a]	451[b]	38	0.00
Total intake	335	480	398	451	451	38	NS
Digestibility coefficients							
Diet	0.61[a]	0.62[a]	0.62[a]	0.65[a]	0.53[b]	0.03	0.05
Mango residue	0.74[a]	0.70[a]	–		0.53[b]	0.05	0.04

Means in the same row with different superscripts are significantly different $P<0.05$

MP mango peels, *MSK* mango seed kernels, *UB* urea block

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source to the diet of broilers containing mango seed kernels increased feed intake and weight gain of the animals.

Sruamsiri and Silman (2009), studying the nutritive value and digestibility of silage of mango peels and seeds, found in vitro digestibility values of 69 and 56 % for peels and seeds of mango, respectively. The value for peels is close to the result in this study in vivo (0.74). Both residues have high digestibility coefficients, suggesting efficient utilization by sheep. This result could be due to the high content of nonstructural carbohydrates (sugar and starch, respectively, in the peels and the kernels), which are easily fermented. Unfortunately, these elements could not be analyzed. However, the addition of a nitrogen source in the diet is very efficient as seen with the diet including urea block. Sruamsiri and Silman (2009) also found that the digestibility of ensiled mango peels with rice straw increased when adding *Leucaena* leave as a protein source.

The protein intake in the different diets was below the requirements. According to Paul et al. (2003), a growing sheep of 20 kg weight, with 50 g of ADG requires 87 g CP/day. The diet containing urea block could fulfill this requirement. The energy content was not evaluated, but the residues were rich in fat and carbohydrates. The experimental period was too short for measuring weight changes, but the fact that the animals did not lose weight suggests that the energy content may be enough for at least maintenance.

Conclusion

Mango peels from dried mango processing units can be a useful feed for animal with regard to its nutritive value and intake characteristics by sheep. The protein content is not enough to cover the requirement, thus the addition of a source of protein is necessary in view to allow efficient utilization of the energy present in this ingredient. The mango seed kernels showed low palatability probably due to the tannin content. It could however be incorporated in a diet in limited amount with the peels and a protein source. Further studies are needed to test the effect of these by-products on long term intake and growth performance of the animals.

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