Omer et al. Bulletin of the National Research Centre (2019) 43:176
https://doi.org/10.1186/s42269-019-0241-4

Bulletin of the National Research Centre

RESEARCH Open Access

Mango (*Mangifera indica*) seed kernels as untraditional source of energy in Rahmani sheep rations

Hamed A. A. Omer, Mohamed A. Tawila, Sawsan M. Gad and Soha S. Abdel-Magid*

Abstract

Background: The present work aimed to investigate the impact of partial replacement yellow corn by mango seed kernels (MSK) at different levels of (0, 25, and 50%) on feed and water consumption, water metabolism, nutrient digestibility, nitrogen balance, and rumen fluid parameters.

Methods: Twelve mature male Rahmani sheep of about 58.39 ± 1.22 kg live body weight on average were used to investigate the influence of replacing yellow corn contents (45% in the control ration) by mango seed kernels (MSK) at different levels (0, 25, and 50%) that equal (0, 11.25, and 22.5% of total ration contents) on feed and water intakes, water metabolism, nutrient digestibility coefficients, nitrogen utilization, and some rumen fluid parameters. The animals were randomly assigned to three experimental groups (four animals in each treatment). Sheep fed rations are composed of 50% concentrate feed mixture (CFM) and 50% peanut vein hay (PVH) at portion 3% dry matter (DM) of live body weight (LBW).

Results: The results showed that values of crude protein (CP), crude fiber (CF), and nitrogen-free extract (NFE) of MSK and yellow corn were similar. Meanwhile, MSK has superior ether extract content compared to yellow corn; meanwhile, ash content of yellow corn was lower than ash content of MSK. All tested CFM were isonitrogenous (16.17% CP), but it differs in their contents of gross and digestible energy. On the other hand, all experimental total mixed rations (TMR) were isonitrogenous (14.52% CP) and isocaloric (4177 kcal/kg DM in average). Dietary treatments significantly ($P < 0.05$) decreased total dry matter intake (DMI) and crude protein intake (CPI) that expressed as (g/h/day, g/kg$W^{0.75}$, and kg/100 kg LBW) or gross energy intake (GEI) and digestible energy intake (DEI) that expressed as (Mcal/h/day, kcal/kg$W^{0.75}$, and Mcal/100 kg LBW). Inclusion MSK in sheep ration insignificantly ($P > 0.05$) increased drinking water by 20% and 6.89% for experimental groups fed TMR_2 and TMR_3, respectively, compared to the control one (TMR_1). Incorporation MSK in the rations significantly ($P < 0.05$) increased insensible losses of water. Dietary treatments significantly ($P < 0.05$) increased nutrient digestibility coefficients of DM, organic matter (OM), CP, CF, and NFE. Meanwhile, it significantly ($P < 0.05$) decreased EE digestibility. On the other hand, both values of total digestible nutrient (TDN) and digestible crude protein (DCP) were significantly ($P < 0.005$) improved. Nitrogen retention (NR) (NR % of nitrogen intake (NI) and NR % of digested nitrogen (DN)) values were significantly ($P < 0.05$) increased with increasing level of MSK in the sheep ration. Inclusion MSK significantly ($P < 0.05$) increased ruminal pH; however, it had no significant ($P > 0.05$) on both ammonia nitrogen (NH_3-N) and total volatile fatty acid (TFVA) concentrations. Sampling time at 3 h post feeding significantly ($P < 0.05$) decreased ruminal pH in comparison with before and 6 h post feeding; meanwhile, sampling time had no significant effect ($P > 0.05$) on NH_3-N concentration. Dietary treatment significantly ($P < 0.05$) increased the interaction between treatments and sampling time for ruminal pH. However, no interaction between treatments and sampling time was observed for both NH_3-N and TVFA concentrations.

(Continued on next page)

* Correspondence: Soha_Syd@yahoo.com
Animal Production Department, National Research Centre, 33 El-Bohouth Street, P.O: 12622, Dokki, Cairo, Egypt

(Continued from previous page)

Conclusion: The present results revealed that replacement up to 50% of yellow corn by MSK as alternative source of energy could be useful in feeding sheep without any adverse effect on digestion and fermentation processing. Also, it can be used to depress the rations cost.

Keywords: Mango seed kernels, sheep, feed and water consumption, water metabolism, digestion coefficients, nitrogen balance, ruminal fermentation

Background

One of the greatest challenges facing the livestock industry in the developing countries is the provision of nutritionally balanced and cost-effective rations, since feed constitutes about 65–80% of the total cost of intensive livestock production The situation has necessitated the need to source for an alternative or partial replacement of one of the most highly competitive feed ingredients such as maize, which contributes about 60–80% of most formulated diets (Durunna et al. 2000; Abdulrashid et al. 2007; Kayode and Sani 2008).

Maize considered or classified that the major energy source in poultry and animal feeds reach to 50 and 55% of most animal feed formula (Bamgbose et al. 2004). It is equally used in human nutrition, thus creating a stiff competition between human and livestock. The resulting effect is high cost translating into high feed cost.

This has necessitated the search for substitutes such as agro-industrial by-products and other farm residues that can replace maize wholly or partly. Some of agro-industrials by products have been established as partial or total substitute for maize such as Mango seed kernel (Farinu et al. 1999; Shittu et al. 2013).

A lot of untraditional feed resources are yet to be inclusion in the feed bank for low-cost animal production. This is because some of them could be gotten free or at very low costs (Orayaga and Anugwa 2014; Orayaga et al. 2015). Agro-industrial by-products such as mango fruit peels (Roa et al. 2003), mango fruit pulp (Soomro et al. 2013), and mango seed kernel (Oluremi and Musa 2004; Diarra and Usman 2008) and other sources of agro-industrials by-products have been identified as feed resources.

Mango (*Mangifera indica*) is an important fruit crop grown in the tropics mostly for its pulp. Mango seed, which represents between 20–60% of the fruit, has limited food or industrial use in most producing countries and is therefore wasted. The kernel contained in the seed (mango seed kernel: MSK) is a good source of carbohydrates (58–80%) and contains moderate quantities of proteins (6–13%) and fat (6–16%). The protein of MSK has a good essential amino acid profile, and its oil is a good source of stearic and linoleic acids (Diarra 2014).

Also, mango seed varied from 20 to 60% of the whole fruit, and the kernel as 45 to 75% of the seed (Maisuthisakul and Gordon 2009), this represents between 4 and 18 million tons of mango kernel available per year, due to its abundance and its limited use as a by-product in most parts of the world (Diarra 2014).

The nutrient composition of mango seed kernel on dry matter basis was evaluated by 6.16% crude protein, 13.63% ether extract, 2.23% ash, and 73.35% nitrogen-free extract (Farinu et al. 1999); however, El-Alaily et al. (1996) noted that the gross energy is 4.7 Kcal/g. On the other hand, Farag (2001) noted that the air-dry mango seed kernels contained CP 70 g/kg, EE 128 g/kg, and tannins 67 g/kg. Also, mango seed kernels contain 6% DCP and 70% TDN, and it is rich in tannins which may vary from 5 to 7%. So it can be used as one of the ingredients in livestock rations (Cheeke 1991; Sindhu et al. 2002).

So, this work was carried out to study the impact of partial replacement yellow corn by mango seed kernels at levels of (0, 25, and 50%) on feed and water consumption, water metabolism, nutrient digestibility, nitrogen balance, and rumen fluid parameters.

Methods

The present experiment was carried out at the Sheep and Goats' Units in El-Bostan area in Nubaria (located on the desert road, 112 km North Cairo city, near from Alexandria) which belongs to the Animal Production Department, National Research Center, Dokki, Giza, Egypt.

Animals and feeds

Twelve mature male Rahmani sheep of about 58.39 ± 1.22 kg live body weight approximately on average were used to establish the impact of replacing yellow corn contents (45% in the control ration) by mango seed kernels at different levels (0, 25, and 50%) that equal (0, 11.25, and 22.5% of total ration contents) on feed and water intakes, water metabolism, nutrient digestibility coefficients, nitrogen utilization, and some rumen fluid parameters. The animals were randomly assigned to three experimental groups (four animals in each treatment).

Sheep fed rations are composed of 50% concentrate feed mixture (CFM) and 50% peanut vein hay at portion 3% DM of live body weight.

Apparent digestibility, nutritive values, and nitrogen balance

Animals were housed in individual metabolic cages. Cages allowed catching feces separately from the urine which was collected in attached glass containers containing 50 ml of 10% sulfuric acid. The digestibility trial consisted of 14 days as a preliminary period followed by 7 days for feces and urine collection.

The animals were fed on 3% of live body weight. Rations were offered in two portions, CFM at 8.00 a.m. followed by main roughage source {peanut vein hay (PVH)} at 9.00 a.m. Water was offered twice daily at 11.00 a.m. and 2.00 p.m. During the collection period, feces and urine were quantitatively collected from each animal once a day at 7.00 a.m. before feeding. Actual quantity of feed intake and water consumption was recorded. A sample of 10% of the collected feces from each animal was sprayed with 10% sulfuric acid and 10% formaldehyde solutions and dried at 60 °C for 24 h. Samples were mixed and stored for chemical analysis. Composite samples of feeds and feces were finely ground prior to analysis. Also 10% of the daily collected urine from each animal was preserved for nitrogen determination. The nutritive values expressed as the total digestible nutrient (TDN) and digestible crude protein (DCP) of the experimental rations were calculated by classical method that described by Abou-Raya (1967).

Chemical analysis (%) of ingredients, concentrate feed mixture (CFM), and experimental total mixed rations (TMR) are presented in Tables 1, 2, and 3. Feeds and water intakes were also recorded during the digestibility trials

Rumen fluid parameters

Rumen fluid samples were collected from all animals at the end of the digestibility trial before feeding (0 h), 3 h post feeding, and 6 h post feeding via stomach tube and strained through four layers of cheesecloth. Samples were separated into two portions, the first portion was used for immediate determination of ruminal pH and ammonia nitrogen concentration, while the second portion was stored at−20 °C after adding a few drops of toluene and a thin layer of paraffin oil till analyzed for TVFAs.

Analytical procedures

Chemical analysis of ingredients, concentrate feed mixture (CFM), experimental total mixed ration (TMR), and feces samples were analyzed according to AOAC (2005) methods.

Ruminal pH was immediately determined using digital pH meter. Ruminal ammonia nitrogen (NH_3-N) concentrations were determined applying NH_3 diffusion technique using Kjeldahl distillation method according to AOAC (2005). On the other hand, ruminal total volatile fatty acids (TVFAs) concentrations were determined by steam distillation according to Warner (1964).

Gross energy (Kcal/Kg DM) calculated according to Blaxter (1968). Each g CP = 5.65 Kcal, g EE = 9.40 Kcal, and g (CF and NFE) = 4.15 Kcal.

Digestible energy (DE) was calculated according to NRC (1977) by applying the following equation: DE (kcal/kg DM) = GE × 0.76.

Neutral detergent fiber (NDF) was calculated according to Cheeke (1987) using the following equation: NDF% = 28.924 + 0.657 × CF%.

Non-fibrous carbohydrates (NFC) were calculated according to Calsamiglia et al. (1995) using the following equation: NFC = 100 − {CP + EE + Ash + NDF}.

Statistical analysis

Collected data of feed and water intake, water metabolism, nutrient digestibility, and nitrogen balance were subjected to statistical analysis as one way analysis of variance using the general linear model procedure of SPSS (2008). Duncan's multiple range test (Duncan 1955) was used to separate means when the dietary treatment effect was significant according to the following model:

$$Y_{ij} = \mu + T_i + e_{ij}$$

where Y_{ij} = observation; μ = overall mean; T_i = the effect of mango seed kernels (MSK) levels for i = 1–3, 1 = control ration contained 45% yellow corn (0% MSK), 2 = replaced 25% of yellow corn by MSK, and 3 = replaced 50% of yellow corn by MSK; and e_{ij} = the experimental error.

Table 1 Chemical analysis of feed ingredients

Item	YC	MSK	UDCSM	WB	PVH
Moisture	11.61	10.36	7.17	10.68	8.44
Chemical analysis (%) on DM basis					
Organic matter	98.60	97.62	94.90	94.98	85.89
Crude protein	9.27	9.24	27.31	14.36	12.85
Crude fiber	2.27	2.90	19.29	8.53	24.78
Ether extract	4.01	10.45	10.33	3.94	2.04
Nitrogen-free extract	83.05	75.03	37.97	68.15	46.22
Ash	1.40	2.38	5.10	5.02	14.11

YC, yellow corn; MSK, mango seed kernel; UDCSM, undecorticated cotton seed meal; WB, wheat bran; PVH, peanut vein hay

Table 2 Composition and chemical analysis of concentrate feed mixture

Ingredients	Mango seed kernel (MSK)		
	0	25	50
1. Composition			
Yellow corn	45.00	37.75	22.50
MSK	---	11.25	22.50
UDCSM	35.00	35.00	35.00
Wheat bran	17.00	17.00	17.00
Limestone	1.50	1.50	1.50
Sodium chloride	1.00	1.00	1.00
Vit. & min. mixture[1]	0.50	0.50	0.50
2. Chemical analysis			
Moisture	9.64	9.51	9.36
Chemical analysis (%) on DM basis			
Organic matter	93.82	93.71	93.59
Crude protein	16.17	16.17	16.17
Crude fiber	9.22	9.30	9.36
Ether extract	6.09	6.82	7.54
Nitrogen-free extract	62.34	61.42	60.52
Ash	6.18	6.29	6.41
Gross energy (kcal/kg DM)	4456	4490	4522
Digestible energy (kcal/kg DM)	3387	3412	3437
Neutral detergent fiber (NDF)	34.98	35.03	35.07
Non-fibrous carbohydrates (NFC)	36.58	35.69	34.81

[1]Each 3 kg vitamins and mineral mixture contains vitamin A 12,000,000 IU, vitamin D_3 2,200,000 IU, vitamin E 10,000 mg, vitamin K_3 2000 mg, vitamin B_1 1000 mg, vitamin B_2 5000 mg, vitamin B_6 1500 mg, vitamin B_{12} 10 mg, pantothenic acid 10 mg, niacin 30,000 mg, folic acid 1000 mg, biotin 50 mg, choline 300,000 mg, manganese 60,000 mg, zinc 50,000 mg, copper 10,000 mg, iron 30,000 mg, iodine 100 mg, selenium 100 mg, cobalt 100 mg, CaCo3 to 3000 g
CFM_1: concentrate feed mixture contained 45% yellow corn
CFM_2: concentrate feed mixture replaced 25% of yellow corn with mango seed kernels
CFM_3: concentrate feed mixture replaced 50% of yellow corn with mango seed kernels
Gross energy (kcal/kg DM) was calculated according to Blaxter (1968). Each g CP = 5.65 kcal, g EE = 9.40 kcal, and g (CF and NFE) = 4.15 kcal
DE (Kcal/kg DM): calculated according to NRC (1977). Using the following equation: DE = GE × 0.76
Neutral detergent fiber (NDF) was calculated according to (Cheeke 1987). Using the following equation:
NDF = 28.924 + 0.657 (CF %)
NFC: non-fibrous carbohydrates, calculated according to Calsamiglia et al. (1995) using the following equation:
NFC = 100 − {CP + EE + Ash + NDF}

Meanwhile, data of rumen fluid parameters was statistically analyzed as two factorial analyses of variance according to the following model:

$$Y_{ijk} = \mu + T_i + S_j + (TS)_{ij} + e_{ijK}$$

where Y_{ijk} = observation; μ = the overall mean; T_i = the effect of mango seed kernels (MSK) levels for i = 1–3, 1 = control ration contained 45% yellow corn (0% MSK), 2 = replaced 25% of yellow corn by MSK, and 3 = replaced 50% of yellow corn by MSK; S_j = the effect of sampling time for j = 1–3, 1 = before feeding (0 h), 2 = 3 h post feeding, and 3 = 6 h post feeding; $(TS)_{ij}$ = the interaction of MSK levels and sampling time; and e_{ijK} = the experimental error.

Table 3 Chemical analysis of the experimental total mixed ration

Ingredients	Mango seed kernel (MSK)		
	0	25	50
Moisture	9.04	8.98	8.90
Chemical analysis (%) on DM basis			
Organic matter	89.85	89.79	89.73
Crude protein	14.52	14.52	14.52
Crude fiber	17.00	17.04	17.07
Ether extract	4.07	4.43	4.79
Nitrogen-free extract	54.26	53.80	53.35
Ash	10.15	10.21	10.27
Gross energy (kcal/kg DM)	4160	4177	4193
Digestible energy (kcal/kg DM)	3162	3175	3187
Neutral detergent fiber (NDF)	40.09	40.12	40.14
Non-fibrous carbohydrates (NFC)	31.17	30.72	30.28

Experimental total mixed ration composed of 50% CFM + 50% PVH
Gross energy (kcal/kg DM) was calculated according to Blaxter (1968). Each g CP = 5.65 kcal, g EE = 9.40 kcal, and g (CF and NFE) = 4.15 kcal.
DE (Kcal/kg DM): calculated according to NRC (1977). Using the following equation: DE = GE × 0.76.
Neutral detergent fiber (NDF) was calculated according to (Cheeke 1987). Using the following equation:
NDF = 28.924 + 0.657 (CF %).
NFC: Non-fibrous carbohydrates, calculated according to Calsamiglia et al. (1995) using the following equation:
NFC = 100 − {CP + EE + Ash + NDF}

Results

Chemical analysis of feed ingredients

Data illustrated in Table 1 cleared that value of crude protein, crude fiber, and nitrogen-free extract of mango seed kernel (MSK) were similar to that of yellow corn. Meanwhile, MSK is superior in their content of ether extract in comparison with yellow corn; the corresponding values of EE were 10.45 and 4.01 for MSK and yellow corn, respectively. On the other hand, ash content of yellow corn was lower than ash content of MSK; the corresponding values of ash were 1.40 and 2.38 for yellow corn and MSK, respectively.

Composition and chemical analysis of concentrate feed mixture

Results of Table 2 showed that MSK replaced 0, 25, and 50% of yellow corn content in basal ration that incorporated at 45% of ration formula. All tested CFM were isonitrogenous (16.17% CP), but it differs in their contents of gross and digestible energy; this relates to different contents of MSK for their content of EE that reach to

10.45% in comparison with that found in yellow corn (4.01%). Also, this may be related to differences in their content of NFE in yellow corn (83.05%) compared to MSK that contained 75.03 % of NFE. On the other hand, NDF content was almost similar in yellow corn and MSK. Meanwhile, non-fibrous carbohydrates (NFC) values were slightly decreased with increasing the level of replacement.

Chemical analysis of the experimental total mixed ration

Data of Table 3 cleared that all experimental total mixed rations (TMR) were isonitrogenous (14.52% CP) and isocaloric (4177 kcal/kg DM in average). Other different nutrients were almost nearly in their values among different TMR for (OM, CF, ash, and NDF. But it slightly differs in their contents of EE, NFE, and NFC.

Feed intake by the experimental groups

Results obtained in Table 4 should be changed to dietary treatments that significantly ($P < 0.05$) decreased CFM and PVH intake; total DMI and CPI that were expressed as g/h/day, g/kgW$^{0.75}$, and kg/100 kg LBW; or GEI and DEI that were expressed as Mcal/h/day, kcal/kgW$^{0.75}$, and Mcal/100 kg LBW. Also in significant ($P > 0.05$), decrease was noticed for both TDNI and DCPI that were expressed as g/kgW$^{0.75}$ and kg/100 kg LBW. Meanwhile, replacement yellow corn by MSK at 25 or 50% significantly ($P < 0.05$) increased both TDNI and DCPI that were expressed as g/h/day.

Water consumption and metabolism by the experimental groups

Dietary treatments had no significant effect on drinking water, feed water, and total water intake that were expressed as ml/h/day; ml/kgW$^{0.75}$; L/100 kg LBW; and L/kg DM intake (as presented in Table 5). However, the present results mentioned that inclusion MSK in sheep ration insignificantly ($P > 0.05$) increased drinking water by 20% and 6.89% for experimental groups fed TMR_2 and TMR_3, respectively, compared to the control one that received TMR_1. On the other hand, water metabolism data showed that incorporation MSK in the rations significantly ($P < 0.05$) increased insensible losses of water, and the corresponding values were 1109, 2604, and 2673 m/h/day for the three experimental group sheep fed TMR_1, TMR_2, and TMR_3, respectively (Table 5).

Nutrient digestibilities and nutritive values of the experimental groups

Data presented in Table 6 cleared that replacement 25 or 50% of yellow corn content in the control ration by MSK significantly ($P < 0.05$) increased nutrient digestibility coefficients of DM, OM, CP, CF, and NFE. Meanwhile, it significantly ($P < 0.05$) decreased EE digestibility. On the other hand, both values of TDN and DCP were significantly ($P < 0.005$) improved when MSK replaced at 25 or 50% of yellow corn content in the control ration.

Table 4 Feed intake by the experimental groups

Item	Mango seed kernel (MSK)			
	0	25	50	SEM
Animal No.	4	4	4	---
Live body weight (LBW), kg	57.83	59.33	58.00	1.22
Metabolic body weight (kgW$^{0.75}$)	20.97	21.38	21.02	0.33
Feed intake				
CFM, g	910	905	907	2.16
PVH, g	909	885	877	12.90
DM intake as				
g/h/day	1819	1790	1784	12.97
g/kgW$^{0.75}$	86.74	83.72	84.87	1.13
kg/100 kg LBW	3.145	3.017	3.076	0.05
TDN intake as				
g/h/day	1217^{b}	1329^{a}	1328^{a}	20.27
g/kgW$^{0.75}$	58.04	62.16	63.18	1.11
kg/100 kg LBW	2.104	2.240	2.290	0.05
CP intake as				
g/h/day	264	260	259	1.90
g/kgW$^{0.75}$	12.59	12.16	12.32	0.16
g/100 kg LBW	457	438	447	7.82
DCP intake as				
g/h/day	187^{b}	201^{a}	194^{ab}	2.49
g/kgW$^{0.75}$	8.92	9.40	9.23	0.14
g/100 kg LBW	323	339	334	5.84
GE intake as				
Mcal/h/day	7.567	7.475	7.480	0.05
kcal/kgW$^{0.75}$	361	350	356	4.97
Mcal/100 kg LBW	13.085	12.599	12.897	0.22
DE intake as				
Mcal/h/day	5.751	5.681	5.685	0.04
kcal/kgW$^{0.75}$	274	266	271	3.77
Mcal/100 kg LBW	9.945	9.575	9.802	0.17

a and b, means in the same row having different superscripts differ significantly ($P < 0.05$); SEM, standard error of the mean; CFM, concentrate feed mixture; PVH, peanut vein hay; DM, dry matter; TDN, total digestible nutrients; CP, crude protein; DCP, digestible crude protein; GE, gross energy; DE, digestible energy

Nitrogen utilization by the experimental groups

Data of Table 7 showed that dietary treatments had no significant effect ($P > 0.05$) on nitrogen intake (NI), fecal nitrogen, and digested nitrogen (DN). On the other hand, urinary nitrogen was decreased with increasing level of substituting of yellow corn by MSK. The present results mentioned that nitrogen retention (NR) (NR % of

Table 5 Water consumption and metabolism by the experimental groups

Item	Mango seed kernel (MSK)			
	0	25	50	SEM
Animal No.	4	4	4	---
Live body weight (LBW), kg	57.83	59.33	58.00	1.22
Metabolic body weight (kgW$^{0.75}$)	20.97	21.38	21.02	0.33
Dry matter intake (DMI), g	1819	1790	1784	12.97
Water consumption, ml				
Drinking water	3742	4492	4000	381
Feeds water	181	177	174	1.60
Water intake as				
ml/h/day	3923	4669	4174	238
ml/kgW$^{0.75}$	187	218	199	10.74
L/100 kg LBW	6.784	7.870	7.197	0.38
L/kg DM intake	2.157	2.608	2.340	0.13
Water metabolism, ml				
Urinary losses, ml	1685	1308	753	202
Feces water, ml	1129^{a}	757^{b}	748^{b}	72.79
Total water losses, ml	2814^{a}	2065^{ab}	1501^{b}	247
Insensible losses, ml	1109^{b}	2604^{a}	2673^{a}	294

a and b means in the same row having different superscripts differ significantly ($P < 0.05$); SEM, standard error of the mean

NI and NR % of DN) values were significantly ($P < 0.05$) increased with increasing level of MSK in the sheep ration.

Rumen fluid parameters of the experimental groups

Data of ruminal parameters are presented in Tables 8, 9, and 10. Replaced 25 or 50% of yellow corn content in the control ration by MSK significantly ($P < 0.05$) increased ruminal pH; however, it had no significant ($P > 0.05$) on both ammonia (NH_3-N) and total volatile fatty acid (TFVA) concentrations. On the other hand, sampling time at 3 h post feeding significantly ($P < 0.05$) decreased ruminal pH in comparison with before and 6 h post feeding; meanwhile, sampling time had no significant effect ($P > 0.05$) on NH_3-N concentration.

Table 6 Nutrient digestibilities and nutritive values of the experimental groups

Item	Mango seed kernel (MSK)			
	0	25	50	SEM
1. Nutrient digestibility coefficient				
DM	86.39^{b}	90.07^{a}	89.66^{a}	0.72
OM	69.83^{b}	78.21^{a}	77.84^{a}	1.49
CP	70.94^{b}	77.49^{a}	74.73^{ab}	1.18
CF	52.80^{b}	65.05^{a}	68.84^{a}	2.64
EE	82.11^{a}	72.37^{b}	76.77^{b}	1.60
NFE	73.94^{b}	83.06^{a}	81.66^{a}	1.54
2. Nutritive values on (DM basis) %				
TDN	66.91^{b}	74.23^{a}	74.44^{a}	1.37
DCP	10.30^{b}	11.25^{a}	10.85^{ab}	0.17

a and b means in the same row having different superscripts differ significantly ($P < 0.05$); SEM, standard error of the mean

Table 7 Nitrogen utilization by the experimental groups

Item	Mango seed kernel (MSK)			
	0	25	50	SEM
Nitrogen intake (NI), g	42.20	41.52	41.39	0.30
Fecal nitrogen (FN), g	12.28	9.35	11.75	0.67
Urinary nitrogen (UN), g	14.86^{a}	13.21^{a}	7.64^{b}	1.31
Total nitrogen excretion, g	27.14^{a}	22.56^{ab}	19.39^{b}	1.43
Digested nitrogen (DN), g	29.92	32.17	29.64	0.66
Nitrogen retention (NR),g	15.06^{b}	18.96^{ab}	22.00^{a}	1.39
NR % of NI	35.69^{b}	45.66^{ab}	53.15^{a}	3.33
NR % of DN	50.33^{b}	58.94^{ab}	74.22^{a}	4.35

a and b means in the same row having different superscripts differ significantly ($P < 0.05$); SEM, standard error of the mean

The present results also showed that incorporation MSK as alternative source of energy for yellow corn significantly ($P < 0.05$) increased TVFA concentration compared to the control that contained yellow corn with 0% MSK (Table 8).

As described in Tables 9 and 10, dietary treatment significantly ($P < 0.05$) increased the interaction between treatments and sampling time for ruminal pH. However, no interaction between treatments and sampling time was observed for both NH_3-N and TVFA concentrations.

Discussion

The present results showed that MSK could be considered a good quality ingredient like yellow corn and could be used in animal ration formulation. Also, these results are in agreement with those noted by Diarra (2014) who reported that mango seed kernel (MSK) is a good source of carbohydrates (58–80%) and contains moderate quantities of proteins (6–13%) and fat (6–16%). Meanwhile, Anigbogu et al. (2006) showed that proximate analysis of *Mangifera indica* kernel content 3.0, 8.13, 73.1, 9.0, and 5.2% for CF, CP, NFE, EE, and ash, respectively. Also, Okoruwa et al. (2015) found that chemical composition of MSK was 5.90% CP, 0.89% CF, 5.46% EE, 2.25% ash, and 76.06% NFE. On the other hand, Farag (2001) found that air-dried mango seed kernels contained 70 g/kg of CP and 128 g/kg of EE. In addition to those literatures on proximate composition of MSK, discuss the implications of the contents. Also, Cheeke (1991) and Sindhu et al. (2002) recorded that mango seed kernels contain 6% DCP and 70% TDN, and it is rich in tannins which

Table 8 Main effects of treatments or sampling time on rumen fluid parameters of the experimental groups

Item	Mango seed kernel (MSK)				Sampling time			
	0	25	50	SEM	Before feeding (0 h)	3 h post feeding	6 h post feeding	SEM
pH	5.84[b]	6.37[a]	6.34[a]	0.07	6.24[a]	6.01[b]	6.30[a]	0.07
NH_3-N (mg/dl)	15.89	13.29	15.74	0.89	13.59	17.30	14.03	0.89
TVFAs (meq/dl)	8.01	9.45	8.78	0.53	6.02[b]	9.57[a]	10.65[a]	0.53

a and b means in the same row having different superscripts differ significantly ($P < 0.05$); SEM, standard error of the mean; NH_3-N, ammonia nitrogen concentrations; TVFAs, total volatile fatty acids

may vary from 5 to 7%, and it can be used as one of the ingredients in livestock rations. Meanwhile, Odunsi and Farinu (1997) reported that mango seed kernel (MSK) contains 5.59% crude protein, 2.13% ether extract, 2.34% ash, 5.32% crude fiber, and 78.62% nitrogen-free extracts and metabolizable energy was determined by 3.17 kcal/g. However, Odunsi (2005) noted that seed kernel contained 61.6 g crude protein, 136.2 g ether extract, 22.3 g ash, 46.4 g crude fiber, 673.5 g nitrogen-free extract/kg. Also, Elegbede et al. (1996) recorded that mango seed kernel had 6.0% protein, 12.8% fat, 32.8% carbohydrate, 2.0% crude fiber, and 2.0% ash. Meanwhile, Dhingra and Kapoor (1985) observed that mango seed kernels constituted about 18% of the total fruit and contained 5% protein and 6–7% crude fat.

Data of Tables 2 and 3 showed that all tested experimental concentrate feed mixture (CFM) and total mixed rations (TMR) were formulated to cover requirements of sheep according to NRC (1985).

Feed intake by the experimental groups were in harmony with those noticed by Anigbogu et al. (2006) who noted that replacement maize with ground *Mangifera indica* kernel significantly ($P > 0.05$) decreased total DMI (g/d/day) and DMI (g/$W^{0.75}$kg). Also, the present results in agreement with those noted by Odunsi and Farinu (1997) who reported that increasing substitution of maize above 30% reduced ($P < 0.05$) feed intake relative to the control of finishing broilers during period (28–63 days). Also, Joseph and Abolaji (1997) recorded that there was no significant difference ($P > 0.05$) in average daily feed intake of chicks that fed diets containing 0% (control), 10% raw, and 15%, 20%, and 25% cooked mango kernels quantitatively substituted for maize. On the other hand, Patel et al. (2004) showed that inclusion of mango seed kernel at 25% of sheep ration significantly increased DMI that was expressed as g/kg $W^{0.75}$, but it insignificantly increased DMI that was expressed as Kg/100 kg. Meanwhile, Saiyed et al. (2003) recorded that receiving weaner kids' diet containing 25% MSK had no significant effect on dry mater intake that was expressed as g/h/day; kg/100 kg live body weight; and g/kg$W^{0.75}$ CP, DCP, and TDN intake.

Data of water consumption and metabolism by the experimental groups that were presented in Table 5 were in harmony with those found by Patel et al. (2004) who reported that incorporation of mango seed kernel at 25% of sheep ration formula significantly increased water intake that was expressed as L/100 kg live body weight, but, in contrast, it insignificantly decreased water intake that was expressed as L/kg DMI. Meanwhile, Saiyed et al. (2003) found that feeding weaner kids' ration containing 25% MSK significantly increased water intake that was expressed as L/h/day, L/kg DMI, L/100 kg live body weight, and ml/kg$W^{0.75}$. Also, anonymous (1993) noted that non-significant average daily water intake per 100 kg body weight by marwari, patanwadi, and merino x patanwadi lambs fattened on either conventional or non-conventional concentrate mixture.

Results of nutrient digestibilities and nutritive values of the experimental groups that presented in Table 6 are not in agreement with those noted by Patel et al. (2004) who showed that inclusion of 25% MSK in weaner lambs ration had no significant effect on nutrient digestibility coefficient of DM, OM, CP, CF, EE, and NFE. Also, they observed that both TDN and DCP were not significantly affected by the incorporation of 25% MSK in the ration

Table 9 Effect of interactions between treatments and sampling time (TxS) on rumen fluid parameters of the experimental groups

Item	Sampling time									
	Before feeding (0 h)			3 h post feeding			6hrs post feeding			
	Mango seed kernel (MSK)			Mango seed kernel (MSK)			Mango seed kernel (MSK)			SEM
	0	25	50	0	25	50	0	25	50	
pH	5.83[b]	6.47[a]	6.43[a]	5.47[c]	6.33[a]	6.23[a]	6.30[a]	6.37[a]	6.37[a]	0.07
NH_3-N (mg/dl)	16.93[ab]	10.91[b]	12.92[ab]	18.93[a]	15.59[ab]	17.38[ab]	11.81[ab]	13.36[ab]	16.93[ab]	0.89
TVFAs (meq/dl)	4.40[d]	6.47[cd]	7.20[bcd]	10.23[ab]	9.40[abc]	9.07[bc]	9.40[abc]	12.47[a]	10.07[ab]	0.53

a, b, c, and d means in the same row having different superscripts differ significantly ($P < 0.05$); SEM, standard error of the mean; NH_3-N, ammonia nitrogen concentrations; TVFAs, total volatile fatty acids

Table 10 Results of ANOVA for rumen fluid parameters of the experimental groups

Item	Main effect		Interaction
	Treatments (T)	Sampling time (S)	(TxS)
pH	**	*	**
NH_3-N (mg/dl)	NS	NS	NS
TVFAs (meq/dl)	NS	**	NS

NS, not significant ($P < 0.5$); *, significant ($P < 05$); **, highly significant ($P < 0.5$); NH_3-N, ammonia nitrogen concentrations; TVFAs, total volatile fatty acids

compared to the control ration that contained 38% corn with 0% MSK. Meanwhile, Anigbogu et al. (2006) noted that feeding sheep rations substituted maize offal at 0, 25, 50, 75, and 100% by Mango (*Mangifera indica*) seed kernel had no significant ($P > 0.05$) on nutrient digestibility coefficients of DM, OM, and CF; however, CP digestibility significantly decreased; but EE and NFE digestibility coefficients were significantly ($P < 0.05$) increased compared to the control one that contained 60% maize offal. On the other hand, Saiyed et al. (2003) observed that inclusion of 25% MSK in weaner kids' ration had no significant effect on all nutrient digestibility coefficients (DM, OM, CP, CF, EE, and NFE) and nutritive values (TDN and DCP).

Nitrogen utilization by the experimental groups (Table 7) were in agreement with those noted by Saiyed et al. (2003) who recorded that weaner lambs that received 25% MSK ration contained in significant improved their nitrogen balance in comparison with the control one. On the other hand, Okoruwa et al. (2013) noted that those values of nitrogen (N) intake (g/day); fecal N output (g/day); urinary N output (g/day); N-balance (g/day); N-balance $BW^{0.75}$; N-retention (g/day); and N-retention (%) were significantly ($P < 0.05$) increased with inclusion mango peels at 32% in West African Dwarf goats ration. In contrast, Anigbogu et al. (2006) noticed that replacing maize offal at 25, 50, 75, and 100% by mango (*Mangifera indica*) seed kernel significantly ($P < 0.05$) decreased nitrogen retention compared to the control one.

The results of rumen fluid parameters of the experimental groups that presented in Tables 8, 9, and 10 were in agreement with those obtained by Omer and Abdel-Magid Soha (2015) who reported that ruminal pH value and ammonia nitrogen concentration significantly ($P < 0.05$) decreased at 3 h post feeding, while total volatile fatty acid concentration significantly ($P < 0.05$) increased at the same time in comparison with the control when Ossimi lambs fed on rations containing different levels (0, 5, 10, and 15%) of dried tomato pomace as agro-industrials by-product used in sheep ration formulation.

Ruminal pH is one of the most important factors affecting the fermentation and influences its functions. It varies in a regular manner depending on the nature of the diet, and on the time, it is measured after feeding and reflects changes of organic acids quantities in the ingesta. The level of NH_3-N and TVFAs as end products of fermentation and breakdown of dietary protein has been used as parameters of ruminal activity by Abou-Akkada and Osman (1967).

The results of ruminal fermentations showed that increasing TVFAs might be related to the more utilization of dietary energy and positive fermentation in the rumen.

The reduction of ammonia nitrogen in the rumen liquor appears to be the result of increased incorporation of ammonia nitrogen into microbial protein, and it was considered as a direct result to stimulated microbial activity, while increasing TVFAs might be related to the more utilization of dietary energy and positive fermentation in the rumen. The addition of more fermentable carbohydrate to ruminant rations causes a decrease in rumen ammonia (Tagari et al. 1964) probably due to a greater uptake of ammonia by rumen microorganisms in support of enhanced microbial growth. The rate of TVFA's production may in this situation exceed the rate of TVFA's absorption through the rumen epithelium, and TVFA's concentration in the rumen juice is increased (Van'tKlooster 1986).

It should be mentioned that TVFA's concentration in the rumen is governed by several factors such as dry matter digestibility, rate of absorption, rumen pH, transportation of the digesta from the rumen to the other parts of the digestive tract and the microbial population in the rumen and their activities (Allam et al. 1984). Increasing of ruminal TVFA's concentration is an indicator for better utilization of dietary carbohydrate as described by Fadel et al. (1987).

Conclusion

It can be concluded that mango seed kernel can be used to replace up to 50% of yellow corn content in the sheep rations without any adverse effect on their feed and water intake, water metabolism, digestion coefficients, nitrogen balance, and ruminal fermentation. Consequently mango seed kernel which is not competing and non-conventional feed stuff for animals was found useful as an economic replacement for energy materials like yellow corn

Abbreviations

%: Percentage; °C: Degree centigrade; CF: Crude fiber; CFM: Concentrate feed mixture; CFM_1: Concentrate feed mixture contained 45% yellow corn; CFM_2: Concentrate feed mixture replaced 25% of yellow corn with mango seed kernels; CFM_3: Concentrate feed mixture replaced 50% of yellow corn with mango seed kernels; CP: Crude protein; CPI: Crude protein intake; DCP: Digestible crude protein; DE: Digestible energy; DEI: Digestible energy intake; DM: Dry matter; DMI: Dry matter intake; DN: Digested nitrogen; g/h/day: Gram per head per day; $g/kgW^{0.75}$: Gram per kilogram metabolic body weight size; GE: Gross energy; GEI: Gross energy intake; h: Hours; Kcal/Kg DM: Kilo calories per kilogram dry matter; $kcal/kgW^{0.75}$: Kilo calories per metabolic body weight size; kg/100 kg LBW: Kilogram per 100 kilogram live body weight; LBW: Live body weight; Mcal/100 kg LBW: Mega calories per 100 kilogram live body weight; Mcal/h/day: Mega calories per head per day; MSK: Mango seed kernels; NDF: Neutral detergent fiber; NFC: Non-fibrous carbohydrates; NFE: Nitrogen-free extract; NH_3-N: Ammonia nitrogen; NI: Nitrogen intake; NR: Nitrogen retention; NRC: National Research Council; OM: Organic matter; PVH: Peanut vein hay; SEM: Standard error of the mean; SPSS: Statistical Package for Social Sciences; TDN: Total digestible nutrient; TFVAs: Total volatile fatty acids; TMR: Total mixed rations; UDCSM: Undecorticated cotton seed meal; WB: Wheat bran; YC: Yellow corn

Acknowledgements
Our deep thanks for the workers of the Sheep and Goats' Units for their help in following up the experimental animals during the trials and team's cooperation and teamwork in many steps to make this work possible.

Authors' contributions
HAAO cooperated in the plane of work, field work, chemical analysis, arrangement data, statistical data, and writing and corrected the MS and helped in the publication. MAT cooperated in the plane of work, field work, chemical analysis, and revision the MS. SMG cooperated in the plane of work and revision the MS. SSA cooperated in the plane of work, field work, and following publication with the journal. All authors read and approved the final manuscript.

Authors' information
Animal Production Department, National Research Centre, 33 El-Bohouth Street, P.O: 12622, Dokki, Cairo, Egypt.

Funding
All authors equally shared in financing the cost of the research paper.

Availability of data and materials
"Not applicable" for that section.

Ethics approval and consent to participate
"Not applicable" for that section.

Consent for publication
"Not applicable" for that section.

Competing interests
The authors declare that they have no competing interests.

Received: 21 August 2019 Accepted: 21 November 2019
Published online: 09 December 2019

References
Abdulrashid M, Agwunobi LN, Jonathan GE, Abdul SB (2007) Carcass quality characteristics of broiler finisher fed taro (Colocasia esculenta) cocoyam meal. In: Book of Abstract of the 32nd Annual Conf Nig Soc Anim Prod (NSAP), held at the University of Calabar, Calabar, Nigeria 32: 457-460

Abou-Akkada AR, Osman HE (1967) The use of ruminal ammonia and blood urea as an index of the nutritive value of proteins in some feedstuffs. J Agric Sci 69:25–31

Abou-Raya AK (1967) Animal and poultry nutrition. 1st Ed. Pub. Dar El-Maarif, Cairo (Arabic text book).

Allam SM, Abou-Raya AK, Gihad EA, El-Bedawy TM (1984) Nutritional studies by sheep and goats fed NoaH treated straw. 1st Egyptian British conference on Animal and Poultry Production, Zagazig 11-13 Sep. P. 53.

Anigbogu NM, Bienstman P, Van Damme B, Ezeokoli CD (2006) Incorporation of dry Mangifera indica kernel in the concentrate ration of growing lambs. Ressources Alimentaires communication 59(1-4):39–42

Anonymous (1993) Development of economic feeding system for meat production from sheep and goats native of Gujarat state and their crossbred using non-conventional feeds. Annual Progress Report, ICAR Adhoc Scheme, Department of Livestock Production, Veterinary College, Gujrat Agricultural University, Anand-India.

AOAC (2005) Official methods of analysis, 18th ed. Association of Official Analytical Chemists, Washington, DC, USA.

Bamgbose AM, Ogungbenro SD, Obasohan EE, Aruna MB, Oteku IT, Igene UF, Otoikhian CSO, Imasuer JA (2004) Replacement of maize offal/cashew nut for maize in broiler diet. Proc 29th Ann Conf of Nig Society of Anim Prod 29: 219–221

Blaxter KL (1968) The energy metabolism of ruminants. 2nd ed. Charles Thomas Publisher. Spring field. Illinois, U.S.A.

Calsamiglia S, Stem MD, Frinkins JL (1995) Effects of protein source on nitrogen metabolism in continuous culture and intestinal digestion *in vitro*. J Anim Sci 73:1819

Cheeke PR (1987) Rabbit feeding and nutrition. Academic Press Orlando, Florida, USA.

Cheeke PR (1991) Applied animal nutrition, feeds and feeding. New York.

Dhingra S, Kapoor AC (1985) Nutritive value of mango seed kernel. J Sci Food Agric 36:752–756

Diarra SS (2014) Potential of mango (*Mangifera indica L.*) seed kernel as a feed ingredient for poultry: a review. World's Poultry Science Journal 70:279–288

Diarra SS, Usman BA (2008) Growth performance and some blood variables of chickens fed raw or boiled mango kernel meal. Int J Poult Sci 7(4):315–318

Duncan DB (1955) Multiple rang and multiple F–test biometrics 11: 1- 42

Durunna CS, Udebibie ABI, Anyanwu GA (2000) Combination of maize/sorghum and cassava tuber meal as a substitute for maize in diet of laying hens. Proceedings of the 25*th* Annual Conference of the Nigerian Society for Animal Production (NSAP). Umudike, March 2000.

El-Alaily HA, Anwar A, El-Banna I (1996) Mango seed kernel as an energy source for chicks. Br Poult Sci 17:129–133

Elegbede JA, Achoba II, Richard H (1996) Nutrient composition of Mango (*Mangnifera indica*) seed kernel from Nigeria. J Food Biochem 19(5):391–398

Fadel JG, Den DU, Robinson DH (1987) Effect of nitrogen, energy supplementation on intake and digestion of oat straw by non lactating ruminant dairy cows. J Agric Sci 106:503

Farag MD (2001) The enhancement of the nutritive value of mango seed kernels for poultry by thermal treatment and radiation processing. Arch Tierernahr 54(1):61–79

Farinu GO, Odunsi AA, Togun VA (1999) Effect of varying levels of mango-seed kernel meal on growth performance, nutrient digestibility and blood components of weaner rabbits. Tropical Journal of Animal Sci 3:119–125

Joseph JK, Abolaji J (1997) Effects of replacing maize with graded levels of cooked Nigerian mango-seed kernels (*Mangifera indica*) on the performance, carcass yield and meat quality of broiler chickens. Bioresour Technol 61(1):99–102

Kayode RMO, Sani A (2008) Physicochemical and proximate composition of mango (*Mangifera indica*) kernel cake fermented with mono-culture of fungal isolates obtained from naturally decomposed mango kernel. Life Science Journal 5(4):55–63

Maisuthisakul P, Gordon MH (2009) Antioxidant and tyrosinase inhibitory activity of mango seed kernel by product. Food Chem 117(2):332–341

NRC (1977) National Research Council. Nutrient requirements of rabbits, National Academy of Science, Washington, D.C.

NRC (1985) Nutrient requirements of sheep. 6th ed. National Research Council, National Academy Press, Washington, DC. USA.

Odunsi AA (2005) Response of laying hens and growing broilers to the dietary inclusion of mango seed kernel meal. Trop Anim Health Prod 37(2):139–150

Odunsi AA, Farinu GO (1997) Assessment of Nigerian mango (Mangifera indica) seed-kernel as a substitute for maize in finishing broiler diets. Ind J Anim Sci 67(7):605–607

Okoruwa MI, Adewumi MK, Njidda AA (2013) Nutrient utilization and growth performance of West African Dwarf goats fed with elephant grass or different proportions of plantain and mango peels. World Journal of Agricultural Sciences 1(6):194–202

Okoruwa MI, Omoragbon E, Obiku A (2015) Effect of *Moringa oleifera* supplementation on acceptability and nutrient utilization of goats fed mango seed kernels. Advances in Life Science and Technology 35:78–83

Oluremi OIA, Musa SA (2004) The effect of mango seed kernel meal on the performance of growing rabbits. J Appl Anim Res 25:61–63

Omer HAA, Abdel-Magid Soha S (2015) Incorporation of dried tomato pomace in growing sheep rations. Global Veterinaria 14(1):1–16

Orayaga KT, Anugwa FOI (2014) The proximate composition of Boerhavia diffusa dried leaves and its effect on the growth performance of weaned rabbits. Proc. 39th Conf., Nig. Soc. for Anim. Prod. 16-19 March, 2014. Babcock Univ. Ilishan-Remo, Ogun State, Nigeria. Eds. A.R. Abdullah, G.O. Tayo, A.O. Akubanjoand O.A. Akinsoyinu. pp 297-300.

Orayaga KT, Oluremi OA, Tuleun CD, Carew SN (2015) The feed value of composite mango (Mangifera indica) fruit reject meal in the finisher broiler

chickens nutrition. African Journal of Food Science and Technology 6 (6): 177-184. DOI: https://doi.org/10.14303/ajfst.2015.054.
Patel KM, Patel KS, Wadhwani KN, Parnerkar S, Pandya PR, Patel AM (2004) Comparative growth performance of weaner lambs on non-conventional based ration under intensive production system. Int J Agric Biol 6(5):860–864 http://www.ijab.org
Roa DS, Ravi A, Yedukondalu R (2003) Inclusion of dried mango peels in finisher rations of pigs on their performance. Indian J Anim Nutr 20(1):120–123
Saiyed LH, Parnerkar S, Wadhwani KN, Pandya PR, Patel AM (2003) Growth and feed efficiency of weaner kids on a non-conventional ration under intensive production system. Int J Agric Biol 5(4):602–607
Shittu MD, Olabanji RO, Ojebiyi OO, Amao OA, Ademola SG (2013) Nutritional evaluation of processed mango (Mangifera indica-Kent) seed kernel meal as replacement for maize in the diet of growing crossbred rabbits. Online J. Anim. Feed Res 3 (5): 210-215. http://www.ojafr.i
Sindhu RA, Khan MA, Nisa M, Sarwar M (2002) Review, agro-industrial by-products as a potential source of livestock feed. Int J Agric Biol 4(2):307–310
Soomro H, Rind MI, Sanjrani SN, Magsi AS, Barham GS, Pirzada SA, Sahito HA (2013) Effect of partial mango pulp mixing in ration on behavior and production of broiler. Inter J plant and Anim Sci 1(2):30–36
SPSS (2008) Statistical Package for Social Sciences, statistics for windows, version 17.0. Released 2008. Chicago, U.S.A.: SPSS Inc.
Tagari H, Driori Y, Ascarelli L, Bondi A (1964) The influence of level of protein and starch in rations for sheep on utilization of protein. Br J Nutr 18:333
Van'tKlooster AT (1986) Pathological aspects of rumen fermentation. In: Neimann-Sorensen A (ed) New developments and future perspectives in research on rumen function. Commission of the European Communities, Luxembourg, pp 259–276
Warner AC (1964) Production of volatile fatty acids in the rumen, methods of measurements. Nutr Abstr And Rev 34:339

Publisher's Note

Springer Nature remains neutral with regard to jurisdictional claims in published maps and institutional affiliations.