Acceptability of Male Circumcision in HIV Prevention Among the Males aged 18 years and above in Mufulira Urban

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ABSTRACT

Objectives and design: The overall aim of this study was to determine the acceptability of male circumcision in HIV prevention among the males aged 18 years and above in Mufulira urban.

A cross sectional study was conducted in Mufulira urban in December, 2009. The study comprised face to face interviews of 407 respondents using a structured interview schedule and two Focus Group Discussions involving males aged 18 to 30 years and those aged 31 years and above respectively. Respondents were drawn from one high density area. The Township was purposively sampled. Systematic sampling was used to select the households. One randomly selected male aged 18 years or older was interviewed from each selected household using a structured interview schedule. Individuals for the FGDs were purposively selected to ensure homogeneity of the group.

The Chi Square test was used to compare the proportions. A result yielding a P value of less than 5 percent was considered to be statistically significant. Data from FGDs were analyzed using Content analysis.

Results: The study revealed that only 18.7 percent of the respondents were circumcised. About 60.7 percent of the respondents expressed willingness to be circumcised if male circumcision could offer partial protection against acquisition of HIV/AIDS. Though knowledge on male circumcision stood at 69 percent, only 26.3 percent of the respondents were specifically aware that male circumcision could reduce transmission of HIV from infected females. There was no significant association between knowledge and willingness to undergo male circumcision. Cultural beliefs in the study did not significantly influence willingness to undergo male circumcision. The only significant association was between improvement in genital hygiene and willingness to undergo male circumcision (OR=2.06; CI [1.09, 3.87]).

Conclusion: though the level of male circumcision is Mufulira urban is on the lower side, the procedure is perceived positively. Acceptability of the procedure in the area is high.

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STUDY BACKGROUND

Introduction and literature review

Though there are a number of strategies that have been put in place to halt the spread of HIV/AIDS, the infection remains unabated. This has stimulated research on additional strategies of preventing the spread of the infection. WHO,UNAID outlines the decision to consider male circumcision as an additional strategy in the prevention of the spread of HIV/AID[1].

A number of observational studies have demonstrated an association between reduced HIV infection and male circumcision. These findings are consistent with the three randomized controlled trials which were done in South Africa Orange farm, Kisumu Kenya and Rakai District in Uganda[2]. It has been further documented that these trials revealed that male circumcision can reduce heterosexual HIV transmission up to 60 percent[3].

WHO suggests that male circumcision should be considered as an important intervention in the prevention of the spread of HIV from females to males[1]. It is believed that male circumcision in sub Saharan Africa can prevent about 6 million new HIV infections and 3 million deaths could be averted over the next 20 years if all men in sub Saharan Africa became circumcised[1].

Following the compelling results from the 3 randomized controlled trials, it is logical to explore acceptability and factors associated with the uptake of male circumcision in Mufulira urban.

MATERIALS AND METHODS

A cross sectional study was conducted in Kantanshi township of Mufulira district involving 407 respondents and 12 from the two Focus Group Discussions. The township was purposively selected because it is a high density area with an estimated population of 8088 of male aged 18 years and above (MDHMT, 2007). At household level, the housing units were systematically sampled from a sampling frame of 3350 housing units. One randomly selected man aged 18 years or older was interviewed using a structured interview schedule guide. Individuals for the FGD were purposively sampled in order to ensure homogeneity of the groups. There were two FGDs, one comprising males aged 18 years to 30 years and the other one involving those aged 31 years and above.

Key words: *Acceptability, Male circumcision*

Quantitative data was analyzed using SPSS version 11. The Chi Square test was used to compare proportions. A result yielding a p value of less than 5 percent was considered to be statistically significant. Qualitative data from the Focus Group discussions were analyzed using Content analysis.

MAIN STUDY FINDINGS

The study showed that knowledge on male circumcision was at 69 percent. However, only 26.3 percent (107) of the respondents knew that male circumcision could offer partial protection against transmission of HIV from infected females to males. Over 85 percent (356) of the respondents felt that male circumcision could improve genital hygiene. About 73.7 percent (300) believed that male circumcision could not adversely affect sexual pleasure. The majority of respondents; 89.2 percent (362) indicated that male circumcision was not a risky procedure if performed in a hospital facility by competent personnel. About 96.1 percent (391) of the respondents believed that it was advisable for circumcised men to use condoms during sexual contact. About 72.7 percent (296) knew of a facility offering male circumcision services. 76.2 percent (310) of the respondents from non circumcising tribes felt that they would not loose their ethnic identity by being circumcised. Only 18.7 percent (76) of the respondents were circumcised. Among the many reasons for being circumcised, 14.3 percent of the respondents stated that they underwent the procedure for hygienic purposes. 60.7 percent (247) of the respondents expressed willingness to be circumcised if it could offer partial protection against HIV. 51.4 percent (209) of the respondents did not express any fear of undergoing male circumcision.

Among the variables under study; Age, marital status, educational level, religion, knowledge on male circumcision, economic status, genital hygiene and socio cultural beliefs, only genital hygiene was statistically significantly associated with willingness to undergo male circumcision (OR=2.06; CI [1.09, 3.87]).

Results from the Focus Group Discussions also revealed that male circumcision has been accepted and is viewed positively by the community. The knowledge level on the procedure was also high. Cultural factors did not seem to influence uptake of male circumcision in this study.

DISCUSSIONS AND CHALLENGES

Though about 2 in 3 respondents had the knowledge on male circumcision, only 16.4 percent were aware that male circumcision could offer partial protection against transmission of HIV from infected females to males. This may be attributed to lack of sensitization of the community on male circumcision as an additional strategy in the fight of HIV/AIDS. There is need to formulate deliberate health messages to promote male circumcisions in the community.

The belief by 87.2 percent of the respondents that male circumcision can lead to improved genital hygiene is likely to facilitate acceptance of the procedure. Furthermore, this study found a statistically association between genital hygiene and willingness to undergo male circumcision. These findings are consistent with those of Caldwell and Caldwell who stated that perceived improved genital hygiene following male circumcision has led to increased demand for the procedure in North Western Tanzania[4]. Similar findings have also been reported in other regions of East and Southern Africa[7].

Several studies have shown that adverse effects following male circumcision may negatively influence the uptake of the procedure[4, 5, 6, 7]. The belief by 73.7 percent of the respondents that male circumcision does not reduce sexual pleasure is likely to promote acceptance of the procedure. According to Kigozi et al male circumcision does not adversely affect sexual satisfaction[8]. It is important to establish the fact that male circumcision does not affect sexual pleasure in order to formulate the right health education messages to promote acceptability of the procedure. In KwaZulu natal, South Africa, the men in an acceptability study who believed that circumcised men enjoy sex more than the uncircumcised ones were more willing to be circumcised[8].

It has been established that risks during or following male circumcision have been cited as possible barriers to acceptability of the procedure[7,9]. The penis is considered to be delicate and men are cautious to have any penile operation as expressed by one participant in the FGD that *"Kubwaume tekwakwangala"* (meaning the penis is not something to play with). It is a good sign from this study that 89.2 percent of the respondents expressed that male circumcision is not a risky procedure when performed in a health facility by competent medical practitioners. This suggests that potential adopters are likely to seek male circumcision services from the right and safe places. Most of the participants in the FGDs also indicated that their preferred choice to access male circumcision services should they opt in were the health centers because of safety reasons.

There are fears that promotion of male circumcision as one of the strategies in the prevention of HIV infection is likely to create a false sense of protection .This may cause circumcised men to engage in risky sexual behavior[10]. Lukobo expressed similar fears that perceptions by some participants in her study that male circumcision is fully protective against HIV has serious implications for acceptability and introduction of male circumcision as an HIV prevention strategy[11]. She emphasizes on the need to educate potential adopters that male circumcision will not fully protect them against HIV acquisition to avoid increase in risky sexual behavior which may result in an increase of HIV incidences. In this study, 96 percent of the respondents felt that even circumcised men should abstain from risky sexual behavior by avoiding unprotected sex. These findings are reassuring and show that responsible sexual behavior can be achieved alongside promotion of male circumcision.

Male circumcision has largely been associated with certain cultural and religious groupings. Some authors have cited ethnic and cultural identity among non circumcising tribes as possible barriers to acceptability of male circumcision[4, 5, 6, 9].

However, 76.2 percent of the respondents from this study believed that they could not loose their ethnic identity by embracing male circumcision. Most of the participants from non circumcising tribes in the FGDs indicated that they were not aware of any tradition discouraging them to undergo the procedure. Culture has been cited as a major factor in acceptability of male circumcision; however, this study does not suggest so. Culture is dynamic and cross cultural interactions that have been going on in the urban settings may influence perception of certain practices that have been viewed as traditional.

This study revealed that only 18.7 percent of the respondents were circumcised. These findings are consistent with the Zambia Sexual behavior survey of 2000 which revealed that only 15.3 percent of the males in the urban areas were circumcised[12]. The uptake of male circumcision is still on the lower side in Mufulira Urban. This can be attributed to inadequate sensitization and lack of a well structured male circumcision Program in the district.

The most expressed reason in this study for having undergone male circumcision among the circumcised respondents was improvement in genital hygiene. These findings are consistent with the study by Lukobo where most of her participants felt that male circumcision improves genital hygiene. It has been detailed that an uncircumcised penis harbors a lot of dirt and pathogenic micro organisms, retains urine and other fluids giving rise to a terrible smel[11]. It is also believed that a circumcised penis is easier to clean. These observations are vital in formulating Public health messages to facilitate acceptability of male circumcision.

In a study done in a South African town with a high HIV prevalence, it was discovered that 59 percent of the participants were willing to be circumcised if the procedure offered partial protection against acquisition of HIV infection[9]. Similar results have been obtained in other sub Saharan African countries[6, 7]. This study has also upheld these findings by showing that 60.7 percent of the respondents expressed willingness to undergo male circumcision if it could offer partial protection against HIV. This shows that though the uptake of male circumcision in Mufulira urban is low, it is perceived positively.

CONCLUSION AND RECOMMENDATIONS

This study revealed an acceptability of 60.7 percent of male circumcision in relation to HIV prevention. The knowledge level on male circumcision was 69 percent. Though the knowledge levels were high, the uptake was on a lower side. During bivariate analysis only improvement in genital hygiene was found to be statistically significant. Based on these findings, the author recommends that information, education and communication strategies should be strengthened by the Mufulira District Health Management Team (MDHMT) placing emphasis on the public health benefits of male circumcision like improvement in genital hygiene and prevention of sexually transmitted illnesses. Acceptability should be increased by increasing the knowledge levels. The DHMT should also develop a well structured and comprehensive male circumcision program.

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REFERENCES

1 WHO, UNAIDS. (2007). New Data on Circumcision and HIV Prevention: Policy and Program Implications. Geneva, WHO, UNAIDS.
2. Bailey, R.C., Nchinya, A., Chola, J.O., Moses, S., Parker, C.B., Agot, K., Maclean, L., Krieger, J.N., Williams, C.F. & Campbell, R.T. (2007). Male circumcision for HIV prevention in young men in Kisumu, Lancet. 369: 643-656.
3. UNAID. (2005). AIDS in Africa: Three scenario to 2025, Geneva, UNAIDS.
4. Caldwell, J.C. & Caldwell, P. (1996). The African AIDS Epidemic, Africa Science. 274: 62-3, 66-8.
5. Nnko, S., Washija, R., Urassa, M. & Boerma, J.T (2001). Dynamics of male circumcision practices in North West Tanzania. Sexually transmitted Diseases 28:214 -8.
6. Kebaabetswe, P., Lockman, S., Mogwe, S. & Mandevu, R. (2003). Male circumcision an acceptable strategy for HIV prevention in Botswana. Sexually Transmitted Infections 79: 214–219.
7. Largade, E., Emmanuel, A.B., Taljaard, C., Puren, T., Adrian, D., Rain – Taljaard, C,., Bertran, & Auvert, A.B.E. (2003). Acceptability of male circumcision as a tool for preventing HIV infection in a highly infected community in South Africa. AIDS Care 15: 315- 327.
8. Kigozi, G., Stephen, W., Chelsea, B., Dennis, B., Kigundu, V., Wawert, M.J., David, S., Nalugonda, F., Kuwanuko, N., Melanie, C.; Ssempijja, V., Makumbia, F., & Gray, H.R. (2007). Male circumcision for HIV prevention, Rakai, Uganda. Sexual medicine 101: 65-70.
9. Rain-Taljaard, R., Largarde, E., Tajard, D.J, C, ampbell, C., MacPhan, C., Williams, B. & Auvert, B. (2003). Potential for an intervention based on male circumcision in a South African with a high level of HIV infection. AIDS Care 15, 315-327.
10. PlusNews. (2006). Zambia: A Snip in time can save lives. PLUSNEWS, March 21, 2006. www. Plusnews. Org/AIDS report.
11. Lukobo, M. Feasibility of setting up male circumcision services in a Government health facility in Zambia. University of Chicago in Illinois. DrPH thesis 2003 7. 11. 10.
12. Central Statistical Office. (2006). Zambia sexual behavior survey 2005, Lusaka, CSO.

Seasonal Variations of Copper and Iron in Goats, Plants and Soil in Siavonga, Southern Zambia

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ABSTRACT

Objectives and study design: The status of Copper and Iron in free ranging goats was evaluated in the rainy, cold dry and the hot dry seasons between November 2009 and June 2010. The objective of the study was to determine the status of Copper and Iron in goat plasma, plant material and soil in Siavonga District of Zambia's Southern Province. This is necessary for establishing baseline data that is essential for formulating ways of supplementing minerals to improve goat production, enhance income generation and to assess whether the consumer of goat meat obtains the essential elements from the meat. Samples were collected in November 2009 (late hot dry season), February 2010 (rainy season) and June 2010 (cold dry season). The samples were analysed for comparative seasonal content of Copper and Iron. In addition to the minerals, soil was also analysed for pH.

Results: Plasma Copper was significantly higher ($p<0.05$) in the wet season (1.11±0.62 mg/L) than in the cold dry (0.04±0.00 mg/L) and the hot dry (0.01±0.00 mg/L) seasons. Iron concentrations were significantly different ($p<0.05$) in all the seasons, the highest was observed in the cold dry season (1.69±0.07 mg/L) and the lowest in the hot dry season (0.54±0.12 mg/L). Plant Copper was significantly higher ($p<0.05$) in the cold dry season (14.24±5.05 mg/kg) than in the hot dry (5.86±0.91 mg/kg) and wet (6.46±0.54 mg/kg) seasons. Iron concentrations were significantly higher ($p<0.05$) in the wet season (904.28±182.48 mg/kg) than in the hot dry (140.13±17.28 mg/kg) and the cold dry (804.38±123.87 mg/kg) seasons. Soil Copper and Iron were significantly higher ($p<0.05$) in the hot dry season (Copper 22.43 ± 1.57 mg/kg; Iron 615.67 ± 61.45 mg/kg) than in the wet (Copper 1.06±0.05 mg/kg; Iron14.22±0.75 mg/kg) and the cold dry (Copper 0.85±0.07 mg/kg; Iron 17.25±2.05 mg/kg) seasons.

Conclusion: Season has been shown to affect concentrations of Copper and Iron in goat plasma, plant material and soil, therefore dietary supplementation should be considered.

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INTRODUCTION

Goat production is increasingly playing an important role in many households in Zambia. Goats have demonstrated resistance to most diseases and a remarkable ability to survive extended periods of drought. Some of the constraints to goat production in Zambia are insufficient feed, inadequate disease control and prevention measures and unsanitary conditions[1]. Browse leaves and pods form a natural part of the diet of goats, which meets over 60% of the forage requirements[2]. Despite the fact that most of the mineral requirements of goats can be supplied by the browse plants, their mineral content is also affected by season and soil type. Supplementation is therefore recommended in many areas especially during the dry season[3-4]. There is however, a lack of knowledge on the status of mineral nutrition in goats in Zambia. Thus, it is necessary to obtain information on the mineral status of goats to establish baseline data that is essential for formulating ways of supplementing minerals to improve goat production, enhance income generation and to assess whether the consumer of goat meat obtains the essential elements from the meat. In this study, the status of Copper and Iron were investigated. This work will provide baseline information to farmers and animal nutritionists on the seasonality of Copper and Iron in goat plasma, plant material and soil, which is essential for formulating supplements to improve productivity. It will also provide a description of Copper and Iron levels in goats for diagnosing deficiencies and toxicities in order to institute corrective or preventive measures.

The objectives of the present study were to compare seasonally, the status of Copper and Iron in goat plasma, plant material and soil in Siavonga District of Zambia's Southern Province.

MATERIALS AND METHODS

Study area and animals of study

The study was carried out in Lusitu and Simamba of Siavonga district, situated approximately 152.4 km south of Lusaka, Zambia. These are rural areas with subsistence farming being the major activity. Animal husbandry is dominated by goat production based on free range management. Siavonga is one

Key words: *Copper, Iron, seasonal variation, Goat plasma, plants, soil, Siavonga.*

of the districts with the largest population of goats in Zambia. The goat population was estimated to be about 45,272 in 2008[5]. The study area has a mountainous landscape, lying about 950 meters above sea level. The climate is characterized by high temperatures of above 29°C and annual rainfall less than 800 mm. Lusitu and Simamba were selected as the study areas because the areas are characterised by very distinct hot dry and wet seasons. The dry seasons are very hot with no grass growing and wet seasons have green bushes. A multistage sampling method was used to sample the goats. The primary sampling units were villages with night shelter and the secondary sampling units were adult female goats aged between two and three years. The sample size for the goats used in this study was calculated using the equation for a study comparing two means[6] ($N=4\sigma^2 (Z_{crit}+Z_{pwr})$□ D^2). Where;

- N is the total sample size (the sum of the sizes of both comparison groups)
- σ is the assumed standard deviation (assumed to be equal for both groups)
- Z_{crit} value is the desired significance criterion
- Z_{pwr} is the desired statistical power
- D is the minimum expected difference between the two means

σ was assumed to be 0.51 which is approximately the average of the standard deviation found between the northern and southern regions of Malawi in a study done on Cattle[7].

A total of 72 goats were recruited into the study. Thirty six of these goats were from Lusitu and the other 36 were from Simamba. To achieve this sample size, five goats were sampled per household in each season. The selected goats were identified using numbered ear tags. This was done in order that the same goats would be sampled at each subsequent visit.

Sample collection and preparation for analysis

Blood sampling

Blood samples were collected in heparinised Vacutainer tubes through jugular venipuncture and plasma was harvested by centrifugation at 1500 rpm for 10 minutes. The plasma was transported to the laboratory in a cool box. At the laboratory, plasma was kept frozen at -20°C prior to analysis.

Plant sampling

Plant samples were collected by cutting grass close to the ground and leaves from browse plants. The **samples** were dried in an oven for 48 hours at 60°C. The dried plant samples were then ground to pass a 1 mm screen mesh and stored in labelled paper bags.

Soil sampling

Soil samples were collected using a stainless steel sampling Auger, at a depth of approximately 20 cm. Soil was collected from ten randomly selected sites at each of the selected villages. The soil was then pooled to come up with one composite sample for each village.

Sample analysis

Plasma and plant sample analysis

Plasma and plant samples were processed by wet digestion using Nitric acid (HNO_3) and Perchloric acid ($HClO_4$). The individual elements were read using an atomic absorption spectrophotometer (Perkin-Elmer, Model 2380).

Soil sample analysis

Copper and Iron were extracted using Diethylenetriaminepenta-acetic acid pentasodium Triethanolamine (DTPA-TEA) extracting solution. Minerals were then determined using an atomic absorption spectrophotometer. Soil pH was determined using Calcium Chloride ($CaCl_2$).

Statistical analysis

Data was analysed using excel and Statistical Package for Social Scientists (SPSS) version 16.0. The one way Analysis of Variance (ANOVA) was used to compare differences in mineral concentration among seasons. Benferroni t tests were conducted to test for significant differences between seasons. The Student's t-test was used to compare means between Lusitu and Simamba. Throughout significance was declared at $p<0.05$.

RESULTS

Plasma

Mean plasma copper (Cu) and iron (Fe) concentrations of Lusitu and Simamba as related to sampling seasons are shown in Table 1.

Table 1: ***Mean plasma Copper and Iron concentrations as related to location and season***

Element	Critical level *	Season	Location: Lusitu [a] Mean ± SEM	Location: Simamba [b] Mean ± SEM	Overall Mean ± SEM
Cu (mg/L)	0.5 -1.5	Wet	0.32 ± 0.19	1.44 ± 0.88	1.11 ± 0.62
		Cold dry	0.03 ± 0.00	0.04 ± 0.00	0.04 ± 0.00
		Hot dry	0.01 ± 0.00	0.01 ± 0.00	0.01 ± 0.00
Fe (mg/L)	1.6 -2.2	Wet	1.04 ± 0.12	0.86 ± 0.10	0.92 ± 0.08
		Cold dry	1.82 ± 0.13	1.61 ± 0.09	1.69 ± 0.07
		Hot dry	0.67 ± 0.18	0.29 ± 0.09	0.54 ± 0.12

*Kaneko, 1980; [a]n =15 (wet season), 30 (cold dry season), 42 (Hot dry season); [b] n =36 (wet season), 43 (cold dry season), 25 (Hot dry season)

Plasma Copper: Cu concentrations were significantly higher ($p<0.05$) in the wet season than in the cold dry and hot dry seasons. There was no significant difference in Cu concentrations between the cold dry and the hot dry season in both localities ($p>0.05$). The goats in Simamba had significantly higher levels of Cu in the wet season than those in Lusitu ($p<0.05$).

Plasma Iron: In Lusitu, plasma Fe was significantly higher ($p<0.05$) in the cold dry season than in the wet and hot dry seasons. In Simamba, plasma Fe showed variation in all the three seasons, the highest ($p<0.05$) being recorded in the cold dry season and the lowest in the hot dry season.

Plants

Thirteen plant species consumed by free ranging goats in Siavonga were collected and analysed. These are listed below with their corresponding Tonga or common names in parentheses.

Lusitu: Balanites aegyptiaca (Mulyanzovu), ***Eleusine coracana (Finger Millet),*** *Azadirachta indica* (Neem tree), *Amaranthus spinosum* (Bbonko), *Lonchocarpus capassa* (Mukololo), *Acacia geradii* (Munyenyengwe), *Xanthocersis zambesiaca* (Munonge), *Berchemia discolour* (Munji), *Tamarindus indica* (Musiika), *Paspalum dilatum* (Mpunga), *Acacia tortilis* (Mukoka).

Simamba: Paspalum dilatum (Mpunga), *Maesopsis eminii* (Muchenje), *Acacia tortilis* (Mukoka), *Colophospermum Mopane* (Mwaani).

Plant data was pooled and means for the two localities were calculated. Mean plant Cu and Fe concentrations as related to sampling seasons and locality are shown in Table 2.

Table 2: ***Mean plant Copper and Iron concentrations as related to season and locality***

			Locality		Overall
			Lusitu Mean ± SEM	Simamba Mean ± SEM	Mean ± SEM
Element	Critical Level*	Season			
Cu (mg/kg)	8-10	Cold dry	18.12 ± 7.30	6.47 ± 1.06	14.24 ± 5.05
		Hot dry	$7.07^{a} \pm 0.77$	$2.23^{b} \pm 1.51$	5.86 ± 0.91
		Wet	$5.46^{a} \pm 0.69$	$7.71^{b} \pm 0.65$	6.46 ± 0.54
Fe (mg/kg)	30-40	Cold dry	853.84±176.33	705.45 ± 137.13	804.38±123.87
		Hot dry	138.01 ± 18.30	146.23 ± 50.26	140.13±17.28
		Wet	610.44 ± 154.30^{a}	1271.60 ± 345.13^{b}	904.28±182.48

*Kessler, 1991; [a,b] Means in the same row with different superscripts differ significantly ($p<0.05$)

Plant Copper: In Lusitu, there were no significant ($p>0.05$) seasonal differences in plant Cu concentrations between the hot dry and wet seasons. In Simamba, Cu concentrations were significantly higher ($p<0.05$) in the wet season than in the hot dry season. Plant Cu was below the required minimum for adult goats in most of the plants during the three seasons (critical level 8-10 mg/kg)[8]. In Lusitu, during the wet season *Balanites aegyptiaca* (1.70 mg/kg DM), *Eleusine coracana* (4.30 mg/kg DM), *Azadirachta indica* (4.80 mg/kg DM), *Amaranthus spinosum* (7.20 mg/kg DM), *Acacia geradii* (3.70 mg/kg DM) and *Xanthocersis zambesiaca* (4.30 mg/kg DM) had Cu concentrations below the critical level. During the same season in Simamba, *Maesopsis eminii* (6.00mg/kg DM) had Cu concentrations below the critical level. In the cold dry season *Acacia tortilis* (4.65 mg/kg DM) did not meet the minimum requirement for Cu. In the hot dry season *Azadirachta indica* (7.60 mg/kg DM), *Eleusine coracana* (4.90 mg/kg DM), *Balanites aegyptiaca* (5.70 mg/kg DM), *Acacia geradii* (6.90 mg/kg DM), *Acacia tortilis* (4.20 mg/kg DM), *Berchemia discolor* (5.00 mg/kg DM) and *Maesopsis eminii* (6.00 mg/kg DM) had Cu concentrations below the critical level.

Plant Iron: Fe was significantly higher in the wet season in Simamba than in Lusitu. In Lusitu, Fe was significantly higher ($p<0.05$) in the cold dry season than in the hot dry season. At $p<0.05$, concentrations of plant Fe in the wet season did not differ significantly than the hot dry and the cold dry season concentrations. In Simamba, no significant seasonal variation ($p>0.05$) in plant Fe was observed. All the plants that were analysed in this study had adequate levels of Fe to meet adult goat requirements (critical level 30-40 mg/kg)[8].

Soil

Mean soil Cu, Fe and pH of both localities as related to sampling seasons are shown in Table 3 at the end of the article.

Season had no significant effect ($p>0.05$) on soil pH in Lusitu and Simamba. Soil pH was lower in Lusitu than in Simamba ($p<0.05$). Lusitu soil had an average pH of 5.99 and Simamba had an average pH of 6.71. The overall average soil pH for the three seasons was 6.26.

Soil Copper: Concentration of Cu was significantly higher ($p<0.05$) in the hot dry season than in the cold dry and wet seasons in both locations. There was no significant difference ($p>0.05$) in Cu concentrations between the cold dry and the wet season in the two locations.

Soil Iron: Concentrations of Fe in soil were significantly higher ($p<0.05$) in the hot dry season than in the cold dry and wet seasons in both locations. There was no significant difference ($p>0.05$) in Fe concentrations between the cold dry and the wet season.

DISCUSSION

Goats in Lusitu had Cu concentrations below the recommended critical level (0.5-1.5 mg/L)[9] in the three seasons, whereas those in Simamba had adequate plasma Cu only in the wet season (1.44 ± 0.88 mg/L). Overall, plasma Cu was only adequate in the wet season (1.11 ± 0.62 mg/L). These concentrations are similar to those reported in Pakistan[10] with a range of 0.34-1.05 mg/L in non-lactating goats. Plasma Cu was high in the wet season despite the goats having a low dietary Cu supply. Low plant and soil Cu may be attributed to leaching of the mineral during the wet season. In the hot dry season, low plasma Cu could have been due to low plant Cu that may have been as a result of low soil moisture which made uptake of minerals by plant roots difficult. In the present study there was a significant seasonal effect on mean plant Cu concentrations with the levels being highest in the cold dry season. Significant seasonal fluctuations in forage Cu concentrations have also been reported in Pakistan[11]. The levels were higher in winter than in summer forage. In winter, the concentration was adequate for goats but found to be borderline to deficient during summer. This is in agreement with the findings of this study which shows that during the cold dry season, all plants except *Acacia tortilis* had adequate levels of Cu. In Indonesia[12], a study reported that concentrations of micro minerals in forages were significantly affected by species and season. Deficiency of forage Cu was found in both the dry and wet seasons. Some plant nutrients are known to influence Cu uptake and subsequent utilisation by plants: phosphate reduces the concentration of Cu in roots and leaves of plants. High levels of Fe and Zn have been found to induce Cu deficiencies[13]. Soil Cu becomes more available with reducing soil pH; deficiencies are therefore rare below about pH 7[11]. This is in agreement with the findings of this study which indicate that Cu was above the recommended critical level (0.75 mg/kg)[13] in the three seasons in both localities. At pH values greater than 8.0, availability of Cu reduces.

During the wet and hot dry seasons, plasma Fe concentrations were below the critical level (1.6-2.2 mg/L)[9] in the two localities. This was despite having a high dietary Fe supply. In goats, Fe deficiency is mainly associated with blood sucking strongyles (*Haemonchus*) that cause undetected blood loss in the faeces. The study goats were free ranging and deworming is rarely done thereby making them susceptible to internal parasites. We therefore speculate that this may have been the cause of the low iron levels observed during the wet and hot dry seasons.

Concentration of plant Fe in the three seasons was higher than the critical level suggested for deficiency of goats. Similar findings were reported in Indonesia which showed high Fe concentrations in forage during the dry and wet seasons[12]. Soil Fe, like Cu, becomes more available with reducing soil pH; deficiencies are therefore rare below about pH 7[13]. But Fe was below the critical level (19 mg/kg)[14] in both localities during the wet and cold dry seasons. there were probably other factors affecting the availability of Fe in the soil. The overall soil Fe values were found to be higher than those reported in Pakistan[15].

CONCLUSION

This study shows that season significantly affects concentrations of Cu and Fe in goat plasma, plants and soil. Plasma Cu was below the critical level in the cold dry and hot dry season, whereas Fe was lower than the critical level in the wet and hot dry seasons. Browse plants provide a valuable food source as they are rich in Fe and can be used to supplement low-quality forages. There may be need to supplement Cu during the wet and the hot dry seasons as most plants had low Cu concentrations during these two seasons. The supplementation of **minerals** should, however, be preceded by animal response studies. Soil Cu and Fe were adequate for plant growth in all the seasons. There is need for future research to investigate why Cu was deficient in plants and plasma in some seasons yet it was adequate in soil.

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REFERENCES

1. Ahmadu B., C.E.A. Lovelace, 2002. Production characteristics of local Zambian goats under semi-arid conditions. Small ruminant Research, 45: 179-183.
2. Aganga A.A., T. Adogla-Bessa, U.J. Omphile and K. Tshireletso, 2000. Significance of browses in the nutrition of tswana goats. Archivos de Zootecnia, 49: 469-480.
3. Aganga, A.A. and E.O. Mcsho, 2008. Mineral contents of browse plants in Kweneng District in Botswana. Agricultural Journal, 3: 93-98.
4. McDowell, L.R., 1997. Minerals for Grazing Ruminants in Tropical Regions, 3rd Edition. Bulletin. University of Florida, 8.
5. DVLD, 2008. Department of Veterinary and Livestock Development. Ministry of Agriculture and Co-operatives, Annual report.
6. Eng, J., 2003. Sample size estimation: How many individuals should be studied? Radiology, 227: 309-313.
7. Mtimuni, J.P., 1982. Identification of mineral deficiencies in soil, plant and animal tissues as constraints to cattle production in Malawi. Ph.D. Dissertation, University of Florida.
8. Kessler, J., 1991. Mineral nutrition of goats. In: P. Morand-Fehr (ed.), Goat Nutrition, Pudoc , Wageningen, Netherlands, EAAP, 46: 104.
9. Kaneko, J.J. (Ed.), 1980. Clinical Biochemistry of Domestic Animals, 3rd edition. Academic press inclusions United States of America: 792-795.
10. Khan Z.I., M. Ashraf, K. Ahmad, I. Javed and E.E. Valeem, 2008. A comparative study on mineral status of blood plasma of small ruminants and pastures in Punjab, Pakistan. *Pakistan Journal of Botany,* 40: 1143-1151.
11. Khan, Z.I., A. Hussain, M. Ashraf, M.Y. Ashraf, L.R. McDowell and B. Huchzermeyer, 2007. Copper nutrition of goats grazing native and improved pasture with the seasonal variation in a semiarid region of Pakistan. Small Ruminant Research, 67: 138-148.
12. Warly, L., A. Fariani, Evitayani, M. Hayashida and T. Fujihara 2006. Mineral status of forages and grazing goats

in West Sumatra, Indonesia: 2. micro minerals. WFL publisher, 4: 204-207.
13. Landon J.R. (Ed.), 1984. Booker Tropical Soil Manual. A handbook for soil survey and Agricultural evaluation in the tropics and subtropics. Booker Agriculture International limited: Longman, Newyork.
14. Conrad, J.H., J.C. Sousa, M.O. Mendes, W.G. Blue and L.R. McDowell, 1980. Iron, manganese, sodium and zinc interrelationships in a tropical soil, plant and animal system. In: L.S. Verde and A. Fernandez (ed.) IV World conference on Animal production, pp 48-53. Buenos Aires.
15. Khan , Z.I., A. Hussain, M. Ashraf, E. E. Valeem, M.Y. Ashraf and M. S. Ahmad, 2004. Soil and forage mineral (trace elements) status of a grazing pasture in the semiarid region of Pakistan. P*akistan Journal of Botany*, 36: 851-856.

Table 3: Soil Copper, Iron and pH as related to season and location

			Locality		
			Lusitu	Simamba	Overall
Element	**Critical level**	**Season**	**Mean ± SEM**	**Mean ± SEM**	**Mean ± SEM**
Cu	0.75*	Wet	1.15 ± 0.03	0.93 ± 0.03	1.06 ± 0.05
(mg/kg)		Hot dry	20.32 ± 1.31	26.65 ± 0.55	22.43 ± 1.57
		Cold dry	0.83 ± 0.12	0.91 ± 0.08	0.85 ± 0.07
Fe	19**	Wet	14.47 ± 1.10	13.85 ± 1.37	14.22 ± 0.75
(mg/kg)		Hot dry	592.75 ± 82.04	661.50 ± 14.50	615.67 ± 61.45
		Cold dry	17.16 ± 3.27	17.39 ± 3.13	17.25 ± 2.05
pH		Wet	6.29 ± 0.65	6.77 ± 0.30	6.48 ± 0.38
		Hot dry	6.01 ± 0.31	6.34 ± 1.14	6.12 ± 0.23
		Cold dry	5.67 ± 0.67	7.01 ± 0.74	6.20 ± 0.54

*Landon, 1984; ** Conrad et al., 1980