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SHORT NOTE [NOTA CORTA]

EFFECT OF SEASON ON SERUM COPPER AND ZINC CONCENTRATIONS IN CROSSBRED GOATS HAVING DIFFERENT REPRODUCTIVE STATUS UNDER SEMIARID RANGELAND CONDITIONS IN SOUTHERN MEXICO STATE

[EFECTO DE LA ESTACIÓN SOBRE LA CONCENTRACIÓN DE COBRE Y ZINC EN SUERO SANGUÍNEO DE CABRAS EN DIFERENTE ESTADO REPRODUCTIVO BAJO CONDICIONES DE PASTOREO EXTENSIVO EN EL SUR DEL ESTADO DE MÉXICO]

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SUMMARY

The effect of season (rainy: RS, and dry: DS) and reproductive status on copper (Cu) and zinc (Zn) concentrations in blood serum of crossbred goats (BW= 36.01 ± 1.59 kg) were studied under semiarid rangeland conditions in Southern Mexico State. Blood samples from 80 crossbred goats were taken each season (RS and DS). The goats were clustered into 10 different groups considering their reproductive status. Concentrations of Cu and Zn in serum were assayed using atomic absorption. Data were analyzed using a general linear model procedure for a completely randomized design and differences among means were examined using a Tukey test. Blood serum concentrations of Cu and Zn were affected by reproductive status and season ($P<0.001$). In relation to the season, Cu and Zn serum levels were lower in RS than DS ($P<0.05$). Overall, kidded goats had the highest values ($P<0.01$) for Cu than other animals in both seasons (RS or DS). Anestrous goats had the lowest concentrations ($P<0.01$) for Zn during RS, while all goats at their second or more kidding, rearing single or twins, showed the highest concentrations of Zn ($P<0.001$) in this season. Adult goats in Southern Mexico State showed a deficiency of Cu and Zn, especially during RS. As such, mineral supplements should be provided with respect to these elements in feeding systems for goats under semiarid rangeland conditions in order to evaluate their impact on health and reproduction.

Key words: Blood serum; goats; season; trace elements.

RESUMEN

El objetivo del presente trabajo fue evaluar el efecto de la estación (Lluvias: RS y Secas: DS) y el estado reproductivo sobre la concentración de cobre (Cu) y zinc (Zn) en suero sanguíneo de cabras (PV = 36.01 ± 1.59 kg) bajo condiciones de pastoreo extensivo en el sur del estado de México. Se tomó muestra de sangre de 80 cabras en cada estación (RS y DS). Las cabras fueron clasificadas en 10 diferentes grupos de acuerdo a su estado reproductivo. La concentración de Cu y Zn en suero sanguíneo fue analizada mediante espectrofotometría de absorción atómica. Los datos fueron analizados usando el procedimiento para modelos lineales generales bajo un diseño completamente al azar, y la diferencia entre medias por el procedimiento de Tukey. La concentración sanguínea de Cu y Zn fue afectada por el estado reproductivo y la estación ($P<0.001$). En general, las cabras lactando tuvieron los valores más elevados ($P<0.01$) para la concentración de Cu que los otros estados reproductivos en ambas estaciones (RS ó DS). Las cabras adultas en anestro tuvieron la concentración más baja de Zn ($P<0.01$) durante RS, mientras que las cabras amamantando en segundo parto con camada sencilla o gemelar mostraron la concentración más elevada en la misma estación. La concentración sérica de Cu y Zn disminuye significativamente ($P<0.05$) durante RS en comparación con DS. Las cabras adultas del sur del estado de México podrían tener una deficiencia de Cu y Zn, especialmente durante RS. En este sentido, atención especial deberá considerarse en la complementación mineral con respecto a estos elementos en los sistemas de alimentación para cabras bajo condiciones semiáridas con el fin de evaluar su impacto sobre la salud y reproducción.

Palabras clave: Suero sanguíneo; cabras; estación; elementos traza.

INTRODUCTION

In semiarid rangelands of southern state of Mexico, the annual rainfall is 1214 mm (INEGI, 2009). During the dry season (October - May), rainfall is scarce (83 mm; INEGI, 2009), leaving most forage withered and reducing the intake of grazing animals to levels too low to meet their energy, protein and mineral requirements. These deficiencies affect animal performance (McDowell, 2003). Some trace elements are activators for enzymatic systems or constituents of organic compounds, and are nutritionally necessary (Underwood and Suttle, 2003). The most common signs of zinc (Zn) deficiency on the reproductive activity of females are erratic, and weak or silent estrus, impaired synthesis/secretion of follicle-stimulating and luteinizing hormones, delayed conception, frequent abortion, gross congenital malformation of fetuses and litter size, despaired gestation length, difficult parturition, uncoordinated uterine impulses or poor uterine activity, preeclampsia, toxemia and low birth weights and/or low offspring survival (Apgar, 1985; Bedwal and Bahuguna, 1994; Smith and Akinbamijo, 2000). Haenlein (1980) showed that pregnant goats consuming diets containing 6 to 7 ppm of Zn do not develop signs of deficiency until they are lactating.

Some reproductive disorders linked to copper (Cu) deficiency in grazing ruminants consist of low fertility associated with delayed or depressed estrus, inhibition of the establishment and/or induction of embryonic loss and fetal death, fetal mummification, placental bleeding and/or necrotic injuries, long post-partum return to estrus, swayback in offspring, as well as lower serum Cu levels prolonging the days to first service, services per conception, and days to conception (Bedwal and Bahuguna, 1994; Smith and Akinbamijo, 2000; Alebic-Juretica and Frkovic, 2005).

In Mexico, the information in mineral nutrition is limited and mineral-related nutritional imbalances could be frequent. Consequently, the reports on mineral status of goats are scarce, and ignore changes in mineral status during different stages of their reproductive cycle and their relationships with season. Hence, this study was carried out to evaluate the effect of season (rainy: RS and dry: DS) on the concentration of Cu and Zn in blood serum of crossbred goats in different reproductive status under regimes of extensive grazing.

MATERIALS AND METHODS

Study area

The study was undertaken in Southern Mexico State, located at 18° 45' N latitude and 100° 12' W longitude, at 1330 meters above sea level. The average annual temperature is 20 °C, and the annual rainfall ranges from 760 to 2218 mm (INEGI, 2009). Flocks of goats were selected by their similar production and feeding conditions (grazing during day and night under confinement without supplementation), as well as by the characteristic that they were maintained in small scale systems with the number of head ranging from 35 to 45 per flock. The study period encompassed the late dry season (April-May) and late rainy season (August-September).

Animals and management

One hundred sixty crossbred goats (BW: pubertal: 22.03 ± 1.02 kg; adult: 34.01 ± 1.11 kg; pregnant: 38.10 ± 3.29 kg; kidded: 36.45 ± 2.02 kg) were selected randomly from flocks under grazing conditions (80 goats were taken each season). Reproductive status of all goats was diagnosed by ultrasound using Draminski® Animal Profi equipped with a mechanical sector probe of 5.0 megahertz, and goats were assigned to one of ten groups based on their reproductive status (Table 1).

Table 1. Groups of grazing goats according to their reproductive status.

Item	Reproductive status
PBG	Pubertal goats from 6-10 months old
AAG	Anestrous adult goats from >12 months old
CLP	Cyclic adult goats during the luteal phase from > 12 months old
CFP	Cyclic adult goats during the follicular phase from > 12 months old
PFP	Pregnant goats in their first pregnancy between 12 and 18 months old
PSP	Pregnant goats in their second or higher pregnancy between 18 and 24 months old
FKS	Kidded goats between 30 and 40 days of their first kidding rearing single (1-2 years old)
FKT	Kidded goats between 30 and 40 days of their first kidding rearing twins (1-2 years old)
SKS	Kidded goats between 30 and 40 days of their second or more kidding rearing single (2-3 years old)
SKT	Kidded goats between 30 and 40 days of their second or more kidding rearing twins (2-3 years old)

Sampling procedures and chemical analyses

Blood samples were collected by duplicate from each goat for season and were obtained by jugular puncture using Vacutainer® needles and tubes. Blood samples were processed by centrifugation at 2,500 revolutions per minute for 10 minutes at 4 °C, and the serum was stored at -20 °C. The frozen serum was thawed, deproteinized with trichloroacetic acid and stored at 4 °C for further analysis (Fick *et al*., 1979). Concentrations of Cu and Zn were measured by atomic absorption spectrophotometry using a Perkin Elmer® Model 210 at a wavelength of 324.8 nanometers for Cu and 213.9 nanometers for Zn (Fick *et al*., 1979).

Statistical model and analysis

Data for mineral concentrations were analyzed using the general linear model (GLM) procedure in SAS (2009) for a completely randomized design with two seasons (rainy and dry) x 10 groups of reproductive status in a factorial arrangement with eight replicates. Differences among means were assessed using Tukey tests (Steel and Torrie, 1980). The statistical model was:

$$Y_{ijk} = \mu + S_i + RST_j + (S*RST)_{ij} + E_{ijk}$$

where Y_{ijk} represents the response variables (Cu and Zn concentrations) for the two seasons (i) for each of the ten reproductive statuses (j); μ = general mean; S_i = effect of ith-season; RST_j = effect of jth-reproductive status; $(S*RST)_{ij}$ = interaction of the ith season with jth reproductive status; E_{ijk} = error-NI (0, σ^2).

RESULTS

Blood serum concentrations of Cu and Zn were 1.15 and 1.22 mg/l, respectively, and were significantly affected by reproductive status, season, and reproductive status/season interaction (Table 2). Cu was higher during the DS (1.37 mg/l) than the RS (0.92 mg/l). Similarly, Zn content was different between DS (1.31 mg/l) and RS (1.13 mg/l). Cu and Zn serum levels increased significantly in kidded and pubertal goats compared to anestrous, cyclic and pregnant goats.

DISCUSSION

The copper and zinc concentrations found during RS and DS are consistent with other studies (Hernández *et al*., 2006; Roy *et al*., 2006; Yazar *et al*., 2006). The overall average blood serum concentration of Cu and Zn found in this study was within the normal range for all ruminants (Cu: 0.8-1.5; Zn: 0.8-1.2) and goats (Cu: 0.9-1.39; Zn: 1.12-2.56) (Underwood and Suttle, 2003; NRC, 2007), and coincides with Hernandez *et al*. (2006), who found normal serum concentrations of Cu and Zn in Creole grazing goats. However, Domínguez-Vara and Huerta-Bravo (2008) reported severe deficiencies of Cu in soil, forage, and sheep grazing in a region near to where the present study was conducted, suggesting results may depend on differences in geographical area, diet consumption, and sampling season; also biochemical and enzymatic changes occurring in blood, as a result of feeding different levels of Cu, appeared to be directly related intrinsic factors in the animal, for example to a degree of liver injury (Solaiman *et al*., 2001).

Cu supplementation studies have shown that the deficiency or excess of this mineral element, can affect daily weight gain and immune functions, which were optimal at supplementation ranging 100 mg (Solaiman *et al*., 2007). Morales *et al*. (2007) also mentions that there are deficiencies of Cu in soil and grasses in various parts of Mexico. Our results may be due to the opportunity for selective browsing because Cu and Zn serum concentrations were unaffected.

Ahmed *et al*. (2001) demonstrated that different physiological states can impose certain demands on animal needs for Cu and Zn. Zn levels were found to be higher in kidded animals (SKT, SKS and FKT) compared to cyclic and pregnant animals. The highest Zn levels obtained in kidded (SKT, SKS and FKT) and pubertal goats with pregnant and cyclic ones could be related to the developing fetus's requirements or low absorption of Zn by pregnant animals (Hostetler *et al*., 2003). Zn levels observed during kidding could be due to high Zn levels released during involution of the uterus (Ahmed *et al*., 2001). Significant differences between kidding groups with pubertal, cyclic and pregnant ones could indicate the highest requirement for Zn in this group, and could be related to the high Zn-binding enzymes necessary for proliferation, growth and development of cells of the mammary gland, and that needed for the immune response to mastitis (Spears and Weiss, 2008).

Even though in the follicular phase of the estrous cycle ovarian tissues require more Zn (Brem *et al*., 2003), no significant differences were found in serum Zn between CFP and CLP. Brem *et al*. (2003) suggest that the mechanism controlling the variation in levels of some minerals during the estrous cycle could be hormonal. According to Ahmed *et al*. (2001), Cu and Zn serum levels can be affected by physiological status, and our results report a similar trend, which in kidded animals (SKT and SKS) led to higher Cu and Zn levels in comparison with the other groups.

The results show a lower concentration of Cu in cyclic goats (CLP and CFP) in contrast to others reporting higher Cu levels during preovulatory and ovulatory periods, possibly due to the transfer of hepatic ceruloplasmin as a result of the increased release of endogenous estrogen (Bhattacharyya *et al*., 1995; Ahmed *et al*., 2001; Ahmed *et al*., 2009). This could explain the low concentrations of Cu and Zn obtained in this study for anoestrus goats and CLP.

Table 2. Serum copper and zinc concentrations (Mean ± S.E.) in crossbred goats according to reproductive status during the rainy and dry seasons.

Item	Copper (mg/l)		Zinc (mg/l)	
Reproductive status/ Season	Rainy	Dry	Rainy	Dry
Pubertal goats	0.69 ± 0.07^{g}	1.30 ± 0.02^{cd}	1.33 ± 0.11^{bcdef}	1.45 ± 0.56^{bcde}
Anestrous adult goats	0.74 ± 0.07^{fg}	0.70 ± 0.02^{g}	0.35 ± 0.09^{i}	1.28 ± 0.47^{bcdef}
Cyclic adult goats during				
luteal phase	0.93 ± 0.12^{efg}	0.83 ± 0.02^{efg}	0.57 ± 0.04^{hi}	1.17 ± 0.37^{cdefg}
follicular phase	0.96 ± 0.08^{defg}	0.97 ± 0.01^{defg}	0.69 ± 0.03^{ghi}	1.14 ± 0.56^{defgh}
Pregnant goats				
first pregnancy	1.01 ± 0.11^{defg}	1.08 ± 0.01^{def}	0.88 ± 0.04^{efghi}	1.14 ± 0.15^{defgh}
second or higher pregnancy	0.96 ± 0.09^{defg}	1.05 ± 0.01^{defg}	0.81 ± 0.03^{fghi}	1.08 ± 0.41^{defgh}
Kidded goats				
first kidding rearing single	1.07 ± 0.06^{def}	1.16 ± 0.01^{de}	0.99 ± 0.04^{defgh}	1.15 ± 0.41^{cdefgh}
first kidding rearing twins	0.86 ± 0.08^{efg}	1.57 ± 0.08^{c}	1.53 ± 0.05^{bcd}	1.46 ± 0.41^{bcde}
second or more kidding rearing single	0.95 ± 0.08^{defg}	2.23 ± 0.06^{b}	1.77 ± 0.10^{ab}	1.73 ± 0.53^{bc}
second or more kidding rearing single	1.05 ± 0.09^{defg}	2.82 ± 0.10^{a}	2.35 ± 0.38^{a}	1.52 ± 0.32^{bcd}

	Probability	
	Copper	Zinc
Season	<0.0001	<0.0001
Reproductive status	<0.0001	0.0004
Season x reproductive status	<0.0001	<0.0001

Values within both columns for the same mineral with different superscripts differ significantly (P<0.05).

CONCLUSIONS

From the present study, it could be concluded that pubertal goats have inadequate blood levels of Cu in the rainy season. The results indicate that anestrous goats, managed under grazing conditions, showed that Cu and Zn serum levels were deficient during rainy and dry season. Cu and Zn serum concentrations were shown to increase throughout pregnancy and lactation in both seasons., The results reflect the different requirements imposed by reproductive status and season interaction on goats. Data presented here, can enhance awareness among small producers regarding the requirements of these micronutrients in their production systems and how to enhance their benefit. Mineral supplements are suggested during the rainy season as is measurement of their impact on the health and reproduction of goats.

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REFERENCES

Ahmed, M.M.M., Hamed, T.F.M., Barri, M.E.S. 2001. Variation of zinc and copper concentrations in the plasma of Nubian goats according to physiological state. Small Ruminant Research. 39:189-193.

Ahmed, W.M., El Khadrawy, H.H., Hanafi, E.M., Abd El Hameed, R., Sabra. , H.A. 2009. Effect of copper deficiency on ovarian activity in Egyptian Buffalo-cows. World Journal of Zoology. 4(1):1-8.

Alebic-Juretica, A., Frkovic, A. 2005. Plasma copper concentrations in pathological pregnancies. Journal of Trace Elements in Medicine and Biology. 19:191-194.

Apgar, J. 1985. Zinc and reproduction. Annual Review of Nutrition. 5:43-68.

Bedwal, R.S., Bahuguna, A. 1994. Zinc, copper and selenium in reproduction. Experientia. 50:626-640.

Bhattacharyya, B.N., Talukdar, S.C., Baruah, S.C. 1995. Studies on circulatory levels of trace minerals at different reproductive status in goats. Indian Journal of Animal Reproduction. 16:96-98.

Brem, J.J., Mestre, J., Trulls, H.E., Pochon, D.O. 2003. Concentración sérica de minerales con relación al ciclo estral en bovinos Brangus. Revista Veterinaria. 14(1):11-13.

Cantú, J.E. 2008. Zootecnia de ganado caprino. Editorial Trillas, México, D.F.

Domínguez-Vara, I.A., Huerta-Bravo, M. 2008. Concentración e interrelación mineral en suelo, forraje y suero de ovinos durante dos épocas en el valle de Toluca, México. Agrociencia. 42:173-183.

Fick, K.R., McDowell, L.R., Miles, P.H., Wilkinson, N.S., Funk, J.D., Conrad, J.H., Valdivia, R. 1979. Métodos de Análisis de Minerales para Tejidos de Plantas y Animales. University of Florida, Animal Science Department, U.S.A.

Haenlein, G.F.W. 1980. Mineral nutrition of goats. Journal of Dairy Science. 63:1729-1748.

Hernández, J.S., Resendiz, R., Carreón, L., Romero, J.O., García, M., Vargas, S., Armendáriz, J., Hernández, J.A. 2006. Cuantificación de niveles séricos de minerales en caprinos criollos bajo régimen de pastoreo extensivo. In: XXXI Jornadas Científicas y X Internacionales SEOC, 20-22 September 2006, Zamora, Spain. pp. 328-330.

Hostetler, C.E., Kincaid, R.L., Mirando, M.A. 2003. The role of essential trace elements in embryonic and fetal development in livestock. The Veterinary Journal. 166:125-139.

INEGI. 2009. Anuario estadístico del Estado de México, edn. 2008. Instituto Nacional de Estadística, Geografía e Informática, Mexico, D.F., ISSN 0188–851X692.

McDowell, L.R. 2003. Minerals in Animal and Human Nutrition, 2nd edn. Elsevier Science B. V., Amsterdam, The Netherlands.

Morales, E., Domínguez, I.A., González-Ronquillo, M., Jaramillo, G., Castelán, O., Pescador, N., Huerta, M. 2007. Diagnóstico mineral en forraje y suero sanguíneo de bovinos lecheros en dos épocas en el valle central de México. Técnica Pecuaria en México. 45:329-344.

NRC. 2007. Nutrient requirements of small ruminants: sheep, goats, cervids, and New World camelids. National Research Council of the National Academies, National Academies Press, Washington, D.C., U.S.A.

Roy, T.J., García, A.J., Bravo, J.A., Soler, F. 2006. Niveles plasmáticos de cobre y zinc en la cabra Retinta Extremeña durante la pubertad. In: XXXI Jornadas Científicas y X Internacionales SEOC, 20-22 September 2006, Zamora, Spain. pp. 383-386.

SAS. 2009. SAS/STAT® 9.2 User's Guide, 2nd edn. SAS Institute Inc, Cary, N.C., U.S.A.

Smith, O.B., Akinbamijo, O.O. 2000. Micronutrients and reproduction in farm animals. Animal Reproduction Science. 60-61:549-560.

Solaiman, S.G., Maloney, M.A., Qureshi, M.A., Davis, G., D'Andrea, G. 2001. Effects of high copper supplements on performance, health, plasma copper and enzymes in goats. Small Ruminant Research. 41:127-139.

Solaiman, S.G., Craig Jr., T.J., Reddy, G., Shoemaker, C.E. 2007. Effect of high levels of Cu supplement on growth performance, rumen fermentation, and immune responses in goat kids. Small Ruminant Research. 69:115-123.

Spears, J.W., Weiss, W.P. 2008. Role of antioxidants and trace elements in health and immunity of transition dairy cows. The Veterinary Journal. 176:70-76.

Steel, R.G.D., Torrie, J.H. 1980. Principles and Procedures of Statistics: A Biometrical Approach. McGraw-Hill, New York, N.Y., U.S.A.

Underwood, E.J., Suttle, N.F. 2003. Los minerales en la nutrición del ganado, 3rd edn. Editorial Acribia, Zaragoza, España.

Yazar, E., Altunok, V., Eroglu, T.. 2006. Concentrations of some elements in blood serum of Angora goats. Medycyna Weterynaryjna. 62:1249-1251.

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