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Quality of Chicken Manure as Cattle Feed and its Effect on Composition of Cow's Milk and Blood Serum in a Dry Tropical Pastoral System

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Abstract: In order to evaluate the quality of chicken manure as animal feed and its effect on chemical and mineral composition of milk as well as on mineral composition of blood serum of dairy cows grazing in dry tropical conditions, 18 dairy cows of similar weight and number of births were studied. The cows were divided into two treatments: T1 = Only grazed and T2 = Grazed+supplemented *ad libitum* with chicken manure. Representative samples of chicken manure were analyzed for chemical and mineral content. In order to evaluate the effect of chicken manure on cattle when used as feed, milk and blood samples were taken every 15 days following a 30 days adaptation period. The milk's chemical composition was characterized using the following variables; urea, casein, fats, protein, lactose, total solids, non-fatty solids, cooling point, density and acidity, all of which were determined with the automated equipment Milko Scan ST-170. Mineral concentration of milk and blood serum was compared by examining values for Ca, Mg, Na, K, P, Cu, Fe and Zn with a Perkin-Elmer 2380 atomic absorption spectrophotometer using the Flame Emission method. In the case of Phosphorous (P), a colorimeter was used with the ammonium vanadate procedure. Results indicated the efficacy of chicken manure as a source of protein and minerals and statistical analysis revealed differences ($p<0.05$) in concentration of urea (3.4 vs. 4.6 mg/100 mL), fats (3.47 vs. 2.24%), total solids (12.23 vs. 11.09%), K (1.53 vs. 2.24 g kg^{-1}) and Zn (3.72 vs.5.22 ppm) in milk produced and in P (0.114 vs. 0.082%) in blood serum between T1 and T2, respectively.

Key words: Supplements, tropics, dual purpose cattle, chicken, manure, Mexico

INTRODUCTION

In cattle raising regions of the state of Chiapas in Southern Mexico, chicken manure is the principal ingredient used in supplements for grazing cattle (Chang, 2009). Such use of chicken manure is a viable option given that it is widely available in the state as one of the country's largest poultry industries has its headquarters in Chiapas. Furthermore, chicken manure is the cheapest feed supplement per unit of nutrient and local farmers consider it to be the most important resource for preventing nitrogen deficiencies in ruminants, above all during the region's critical dry season.

In general, information regarding cattle shows that chicken manure may be used as a supplement for correcting protein or mineral deficiencies in grass or other fibrous plants in the animals' diet. Whether used as part of the basic diet or as a supplement, results have confirmed the benefits of chicken manure in cattle nutrition and production systems (Alvarez and Combellas, 2003). Nevertheless, quality of chicken manure is altered by many factors, making its' nutritional value highly variable (Alvarez, 2001). Therefore, it is recommended that manure be evaluated prior to use in order to guarantee a more effective feeding strategy.

In Chiapas, chicken manure is included in the diets of most ruminants raised for meat but above all in those raised for milk. However in the majority of cases, this feed resource is managed incorrectly, given that farmers are generally unaware of its chemical composition and in many cases it is offered *ad libitum* without awareness of potentially harmful effects to the animal (Chang, 2009). Nevertheless, few studies report scientific data regarding chemical composition of this feed resource and even

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fewer report repercussions of dairy cattle consuming chicken manure in large quantities, despite the suspicion (which has not been scientifically demonstrated) that possibly toxic elements in chicken manure may contaminate milk, affecting the quality of dairy products made from this milk. Therefore, there is an urgent need to identify these potentially toxic elements due to their possible impact on animal and human health.

With this in mind, the objective of this study was to characterize the quality of chicken manure produced in Chiapas and identify the effects of its use as a supplement used *ad libitum* on the characteristics of milk and blood serum of cows grazed in the dry tropics.

MATERIALS AND METHODS

This study was carried out in the Frailesca region the central valleys of the state of Chiapas, Mexico. This region is located between 16°0' and 16°30'N latitude and 93°0' and 93°30'W longitude. Climate is predominantly warm sub-humid with summer rains, corresponding to the Aw climate in the Koppen climatic classification as modified by Garcia. The region is characterized by rain from May to October with a mean annual precipitation of 1,100 mm and a dry season from January to April. Mean annual temperature is 25°C with a minimum of 18°C and a maximum of 27°C.

In order to carry out a nutritional characterization of the chicken manure, sampling was carried out in 19 chicken farms located in the study region which belong to the largest poultry company in Chiapas. These farms constitute 15% of the farms owned by this company. All farms sampled used the same management practices with respect to the chickens (breed, sanitary program and feeding program), physical plant and equipment and handling of manure. Samples were taken throughout the dry season, just before the chickens were to be sold. Composite samples were obtained by duplicate and analyzed in order to determine content of Raw Protein (RP) and Organic Matter (OM) (AOAC, 1990). Fractions of Neutral Detergent Fiber (NDF) and Acid Detergent Fiber (ADF) were analyzed according to the technique of Van Soest *et al.* (1991). In order to measure ruminal Degradation of Dry Matter (DMD), the plastic bag technique was used (Orskov and McDonald, 1979). Disappearance of dry matter was expressed as a percentage and estimated according to the difference between existing quantity of dry matter incubated minus quantity of residual matter. Content of Calcium (Ca), potassium (K), sodium (Na), Magnesium (Mg), Manganese (Mn), copper (Cu), iron (Fe) and zinc (Zn) were determined using an atomic absorption spectrophotometer by the Flame Emission method (Perkin-Elmer Corporation, 1987). Phosphorus (P) was estimated by a colorimeter using the ammonium vanadate procedure. Chemical component data was analyzed using descriptive statistics (Senecore and Cochran, 1981). In order to evaluate the effect of supplementing the diet of dairy cattle with chicken manure, the researchers used a 19 ha pasture established with a monoculture of African Star grass (*Cynodon plectostachyus*) in soil classified as Haplic Feozem.

The study was carried out during the dry season (January to April) using 18 cows which were a Swiss American-Holstein cross with an average live weight of 420 (±25) kg and an average age of 4 (±0.9) years, all in lactation with 2 or 3 months old calves which were a product of their first or second birth.

Cows were randomly selected and divided into two treatments with nine animals each with each cow representing the experimental unit. Treatments (T) evaluated were; T1 = Only grazing and T2 = Grazing+ chicken manure provided *ad libitum*. Prior to the experiment, the cows of both treatments were submitted to a 4 months detoxification period consisting of continuous grazing with the goal of eliminating possible effects of chicken manure in animals which may have consumed manure previous to the study. Posteriorly, T2 animals were submitted to a 20 days period of adaptation to consumption of chicken manure.

At the beginning of the experiment, all cows were externally deparasited with Amidin; this was repeated every 15 days. They were internally deparasited with Ivermectin at a dosage of 1 mL/50 kg LW/animal. Furthermore, they were vaccinated against the region's most common diseases: Derriengue (using Cepa Roxane at a dosage of 2 mL/animal) and Pasteurella, symptomatic carbon and malignant Edema (using triple bacterine at a dosage of 5 mL/animal).

During the experimental period, all animals remained under pasture under a system of rotational grazing, controlled for carrying capacity by using electric fences. Each treatment grazed in a different group of pastures. In the areas assigned to T2 animals, chicken manure was continually placed in feeders to which the animals had free access and consumption was recorded. All cows were milked by hand from 6:00-8:30 a.m. with the presence of the calf as is the typical practice in the study region.

Samples of milk (100 mL) and blood (5 mL) were taken from each animals monthly. Milk samples were collected at 7:30 a.m. and deposited in 100 mL plastic containers previously washed with deionized water. Blood samples were obtained by piercing the animal's jugular vein using 5 mL vacutainer tubes with an anticoagulant (heparin) in order to isolate the blood serum. Variables evaluated for milk samples were urea, casein, protein, fats, lactose, total solids, density, non-fatty solids, cooling point and acidity, all of which were determined with the previously standardized automated equipment Milko Scan FT2. Minerals analyzed in the milk and blood serum were Ca, Na, K, Mg, Cu, Fe and Zn, using the Flame Emission method (Perkin-Elmer Corporation, 1987) while Phosphorus (P) was estimated using a Colorimeter with the ammonium vanadate procedures. Results were analyzed using the Student t-test for independent samples with the SAS, statistical package (SAS, 1988).

RESULTS AND DISCUSSION

Cows' levels of consumption of chicken manure when offered *ad libitum* was on average 6.9 kg/cow/dia throughout the experiment.

Chemical composition of chicken manure: Table 1 shows the chemical composition of chicken manure evaluated in this study. In general, values were within the ranges reported by several other studies (Martin *et al*., 2000; Gerig *et al*., 2000; Tobia and Vargas, 2001; Morales *et al*., 2002; Rios *et al*., 2005). High values for RP (29.78%) are characteristic of chicken manure which may be offered in order to cover protein requirements for ruminants. Regarding OM, values <80% indicate less energy and protein, the most costly and critical aspects of ruminant feeding (Morales *et al*., 2002).

Low values for fiber fractions compared to those reported by other studies (24.6% for ADF according to Deshck *et al*. (1998) and 33.7% for NDF according to Brosh *et al*. (1993) could be explained by the fact that the farms where the manure is produced do not use poultry litter, keeping in mind that type of litter affects nutrient content of chicken manure, above all protein and fiber levels (Fontenot *et al*., 1983). Values for DMD *in situ* at two schedules of ruminal degradation (24 and 48 h) reinforces the fact since a strict relation has been reported between low fiber values and high ruminal degradation values. Values reported are high (85.81 and 89.06% at 24 and 48 h, respectively) in comparison with values reported by Morales *et al*. (2002) (67%), indicating high nutrient contribution of chicken manure to the animal's rumen. In general, manure evaluated may be considered to be high quality, since its RP level is close to 30% and that of OM is close to 80% which may suggest a metobolic energy content >2.0 Mcal kg^{-1} (Morales *et al*., 2002). Table 2 shows mineral composition of chicken manure evaluated in this study. In general, manure showed high mineral values, sufficient to replace the usual mineral supplements in animal feeding (Rios *et al*., 2005), since when freely consumed, chicken manure may potentially cover 100% of daily requirements of the majority of macro and micro-minerals (Pinto, 1995). Data confirm that chicken manure is especially rich Ca (Mendez *et al*., 2004) and provides a high level of available phosphorous (Pacheco *et al*., 2003). It is also very high in K, Fe, Zn and Mn while values for Na and Mg are within the average range reported by the literature (Garcia, 1993). While chicken manure is generally characterized by its high content of Cu which may provoke toxicity, this study reported lower Cu values (63.49 ppm) than the average values reported for chicken manure produced in the Mexican states of Yucatan (Moguel *et al*., 1994) and Morelos and Veracruz (Aguiar *et al*., 1987). This could be due to the fact that the Chiapas farms monitor use of

Table 1: Chemical composition and ruminal degradation (% dry base) of chicken manure used as a supplement in grazing dairy cattle in the dry tropics

Chemical component	Mean	Standard deviation	Variation coefficient	Minimum	Maximum
Raw protein	29.78	1.88	6.31	27.65	32.00
Organic matter	81.74	1.28	1.57	80.34	84.54
Neutral detergent fiber	21.64	3.32	15.34	16.00	28.60
Acid detergent fiber	9.76	2.43	24.90	5.00	14.40
Ruminal degradation at 24 h	85.81	1.69	1.97	84.14	88.36
Ruminal degradation at 48 h	89.06	1.80	2.02	87.28	91.78

Table 2: Mineral composition (dry base) of chicken manure used as a supplement in grazing dairy cattle in the dry tropics

Mineral	Mean	Standard deviation	Variation coefficient	Minimum	Maximum
Calcium (%)	2.69	0.31	11.52	2.32	3.26
Phosphorus (%)	1.44	0.09	6.25	1.27	1.55
Magnesium (%)	0.59	0.06	10.17	0.51	0.69
Potassium (%)	3.02	0.26	8.61	2.52	3.26
Sodium (%)	0.62	0.05	8.06	0.51	0.67
Manganese (ppm)	649.43	64.13	9.87	558.62	769.17
Copper (ppm)	63.49	14.31	22.54	40.66	97.74
Iron (ppm)	1531.08	82.45	5.39	1432.95	1727.73
Zinc (ppm)	516.65	48.76	9.44	463.03	611.20

Table 3: Mineral composition of blood serum in grazing cows which receive or do not receive supplements of chicken manure in the dry tropics

Minerals	T1	T2	p-values
Ca (mg dL^{-1})	9.00	9.66	NS
P (mg dL^{-1})	7.90	10.50	0.001
Mg (mg dL^{-1})	2.00	2.00	NS
Na (mg dL^{-1})	300.66	312.00	NS
K (mg dL^{-1})	28.00	30.66	NS
Cu (μg dL^{-1})	0.66	0.74	NS
Fe (μg dL^{-1})	4.34	7.40	NS
Zn (μg dL^{-1})	1.24	1.24	NS
Ca:P relation	1.1:1	0.9:1	-

T1 = Non-supplemented cows; T2 = Cows supplemented *ad libitum* with chicken manure; P = Probability; NS = Not Significant

copper sulfate in chicken feed and water during the dry season when this study was carried out (Pacheco *et al*., 2003). Fe and Zn values were much higher than those reported by Pacheco *et al*. (2003), Garcia (1993) and Moguel *et al*. (1994). These high levels could interfere with intestinal absorption of dietary Cu (Bremner *et al*., 1987). This could allow for elevated levels of chicken manure to be used in the region for prolonged periods without apparent problems for the dairy cattle (Chang, 2009).

Effect of chicken manure used as a dietary supplement in cows on mineral composition of their blood serum: Mineral composition of blood serum did not show significant differences between treatments with the exception of phosphorous whose value in T2 (10.50 mg dL^{-1}) was greater ($p<0.001$) than that of T1 (7.9 mg dL^{-1}) (Table 3). These results appear to confirm that reported by Segura who found that P in chicken manure is available for grazing ruminants due to its chemical formula in the manure (Barnett, 1994).

Values obtained in T1 for Ca (9.00 mg dL^{-1}), P (7.90 mg dL^{-1}) and Na (300.66 mg dL^{-1}) when compared with levels considered by McDowell *et al*. (1993) and Bufforini *et al*. (2008) to be critical (Ca: 8.00-9.50 mg dL^{-1}; P: 4.00-7.55 mg dL^{-1} and Na: 303 mg dL^{-1}) indicate that they are close to deficiency levels. T2 animals showed blood mineral values above deficiency levels (Ca: 9.6 mg dL^{-1}; P: 10.50 mg dL^{-1} and Na: 312 mg dL^{-1}). This difference could be associated with the high values of these minerals found in the chicken manure evaluated (Table 2).

Levels of Mg and K in both treatments were >1.8 and 15 mg dL^{-1} respectively which have been suggested by McDowell *et al*. (1993) to be critical levels. With respect to micro-minerals, Cu values in both treatments (0.66 and 0.74 mg dL^{-1} for T1 and T2, respectively) were below the critical level (McDowell *et al*., 1993) (0.80 μg dL^{-1}) which coincides with the fact that a large percentage of animals in the region have been reported to have Cu deficiencies (Pinto, 1995) and that chicken manure as a dietary supplement does not improve this condition, possibly due to its low Cu content (63.49 ppm) and due to the effects of Fe and Zn, minerals found in high quantities in the manure which may interfere with intestinal absorption of Cu.

Table 4: Mineral composition of milk of grazing cows which receive or do not receive supplements of chicken manure in the dry tropics

Minerals	T1	T2	p-values
Ca (g kg^{-1})	1.67	1.60	NS
P (g kg^{-1})	1.18	1.25	NS
Mg (g kg^{-1})	0.12	0.13	NS
Na (g kg^{-1})	0.61	0.65	NS
K (g kg^{-1})	1.53	2.24	0.002
Cu (ppm)	0.12	0.09	NS
Fe (ppm)	2.47	1.86	NS
Zn (ppm)	3.72	5.22	0.001

T1 = Non-supplemented cows; T2 = Cows supplemented *ad libitum* with chicken manure; P = Probability; NS = Not Significant

Effect of chicken manure used as a dietary supplement in cows on mineral composition of milk: With respect to minerals in the milk, values found in this study for Ca and P in both treatments (Table 4) were greater than those reported by other researchers (Taverna *et al*., 2001), a fact which may be associated with the level of milk production and the physiological state of the animals used in this study as well as their diet. However, values for Mg, K and Na were similar in this study to those of the studies by the researchers mentioned before. Only levels of K and Zn showed statistically significant differences between treatments ($p<0.002$). Differences in mineral concentrations found between blood serum and the milk could be explained by the fact that the minerals pass from the blood to the milk through active transport systems.

Effect of chicken manure used as a dietary supplement in cows on chemical composition of milk: In general, data for some components of milk (protein, fats, total solids and non-fatty solids) are within ranges reported in other studies which evaluate milk quality under a variety of conditions (Hernandez *et al*., 1998; Gonzalez *et al*., 2002) in cows of the same genetic breed as those used in this experiment. In this study (Table 5), only levels of urea, fats and total solids showed significant differences between treatments ($p<0.05$). According to Pedraza *et al*. (2006) when cows are adequately fed, urea content of milk should be 15-30 mg/100 mL and the milk should have 3.2% or more protein.

Values for T1 were close to this range. Nevertheless, the value for T2 (46 mg/100 mL) is much higher than that suggested by Chapa *et al*. (2001) which could indicate an excess of degradable nitrogen in the manure and a deficiency of fermentable carbohydrates in grass which grows during the dry season.

Table 5: Chemical composition of milk from grazing cows which receive or do not receive supplements of chicken manure in the dry tropics

Milk components	T1	T2	p-values
Urea (mg/100 mL)	34.000	46.000	0.006
Casein (%)	3.030	2.730	NS
Fats (%)	3.470	2.240	0.03
Protein (%)	3.770	3.260	NS
Lactose (%)	4.420	4.400	NS
Total solids (%)	12.230	11.090	0.001
Non-fatty solids (%)	9.020	8.820	NS
Cooling point	0.580	0.540	NS
Density at 15°C (g)	1.031	1.031	NS
Acidity (g/100 mL)	0.130	0.130	NS

T1 = Non-supplemented cows; T2 = Cows supplemented *ad libitum* with chicken manure; P = Probability; NS = Not Significant

High values of urea in milk such as those found in this study could affect milk processing (Pena, 2002). In studies of grazing cows, Wittwer *et al*. (1993) found an average of 36.7±12.2 mg/100 mL values quite similar to those found for T1.

This study showed a relationship between level of protein and urea in milk; a greater level of urea has been reported for animals with levels of milk protein <3.2% and low levels of urea have been reported in animals whose protein level surpasses 3.2%, coinciding with that described by Pedraza *et al*. (2006) and Hojman *et al*. (2004). With respect to fat levels, a study (Smith and Wheellers, 1979) of dairy herds fed with chicken manure compared to the control herd (without manure) reported similar fat content (3.73 vs. 3.80%, respectively) which contrasts with that reported in this study. This may have been associated with palatability of the diets used in both studies and therefore with the consumption of chicken manure. In T2, content of fat and total solids diminished by 35.5 and 9.4%, respectively. This response may be associated with greater milk production in T2 animals which in this experiment was 1.5 times greater than that of un-supplemented cows since, milk fat generally decreases when milk production increases.

CONCLUSION

Based on results obtained in this study, the researchers may conclude that chicken manure is an important source of protein and minerals for ruminants and when offered *ad libitum* to cows, it produces changes in concentration of urea, fats, total solids, K and Zn in milk produced and P in blood serum of cows grazing during the dry season.

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