Growth Performance of Broiler-Chickens Fed Cassava Starch residue Leaf meal as a Replacement for maize diet

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ABSTRACT

A 42-day trial using 300 day old broiler chickens was conducted to evaluate the nutritive potential of cassava starch residue and cassava leaf mix on their performance characteristics. The birds were divided into 6 treatment groups and further replicated 5 times with 10 birds per replicate in a completely randomized design and fed diets containing 0, 10, 20, 30, 40 and 50% Cassava Starch Residue Leaf Meal (CSRLM) (95:5) mix as a replacement for maize diet. The birds were adequately housed, while feed and water were supplied ad-libitum. Other standard management practices were adequately put in place. The results show that final body weights of birds are significantly influenced by dietary treatments. The values recorded for broiler chickens fed the control diet (1970g/bird) is higher than values obtained for bird fed the test (1424 - 1660g/bird). Average daily weight gain is also significantly affected by dietary treatments with the control diet recording the best value. No significant difference is observed across dietary treatments for Average Daily Feed Intake (ADFI). Birds fed the control diet have a higher ADFI and this decreased with increased replacement of maize with the CSRLM (95:5) mix. The FCR for bird fed the control diets is significantly better than those fed the test diets.

Keywords: *Growth performance, broiler chickens, cassava starch residue, cassava leaf, maize*

INTRODUCTION

Broiler performance in terms of weight and efficiency of gain is clearly related to the intake levels and therefore intake of particular nutrients particularly energy and protein. However, the feed stuffs and ingredients used in broiler rations formulation such as maize, soybean meal, groundnut cake etc. have continued to be scarce and costly due mainly to their low production and competition as food for human beings. In Nigeria, due to the scarcity and high cost of conventional ingredients, there is a renewed interest in the use of non-conventional cheap and easily available ingredients in broiler feeding. Cassava products have been in use for a long time as an energy source in place of cereal grains for livestock (Eruvbetine, Tajudeen, Adeosun and Olojede, 2003) and will continue to be used in animal feeding in the 21st century and beyond. The processing of starch from cassava roots has brought about the vast production of cassava starch residue which also has great potentials in livestock feeding. Cassava starch residue

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however, is deficient in protein and essential amino acids. The supplementation of cassava starch residue with cassava leaf which is high in carotene and protein is one of the ways of addressing these deficiencies (Omole, 1977). Cassava leaf is known to produce very high amounts of protein even in the dry season in situations where no irrigation or fertilization in practiced (Wyllie, 1979). Therefore, upgrading of cassava starch residue with the leaf meal could result in a product that could serve as a good substitute for maize. This study therefore aims at evaluating the performance of broiler chickens fed with the mixture of cassava starch residue and cassava leaf in a ratio of 95:5 as a replacement for maize.

MATERIALS AND METHOD

Cassava Starch Residue (CSR) was obtained from a cassava starch processing industry in Ogbese, Ondo State, Nigeria, drained with hydraulic press, sun-dried and ground. The cassava leaves obtained from the Teaching and Research Farm of College of Education, Ikere, Ekiti State were sundried and milled. These cassava wastes were characterized with respect to their proximate composition, nutritionally needed minerals and anti-nutritional factors, using standard methods. Thereafter, cassava starch residue mixed with cassava leaves in ratio 95:5 were used to replace maize at 0, 10, 20, 30, 40 and 50% in the diets of growing broiler chicks, and designated as diets 1, 2, 3, 4, 5 and 6 respectively.

A total of 300 – day old broiler chicks were used for the experiment. All the chicks were electrically brooded at the Teaching and Research Farm of the Federal University of Technology, Akure, where they were fed with the commercial feed for the first week pre-experimental period. At the end of the pre – experimental period, the chicks were weighed and 50 chicks were randomly assigned to each of the 6 diets in 5 replications of 10 chicks per replicate. The mean group weights per diet were identical (137.5g). The chicks were fed with their respective experimental diets *ad libitum* for 42 days. Water was provided adequately and a record of daily feed consumption was taken and also group weight changes were taken every 7 days. All data collected were subjected to Analysis of variance (Steel and Torrie, 1960). Where significant ($P < 0.05$) differences were obtained, means were compared using Duncan Multiple Range Test (DMRT) (Duncan, 1955).

RESULTS AND DISCUSSION

Table 6 shows the performance of the birds from day 7-21 with respect to weight gain, feed consumption and feed efficiency of the broiler starter chicks at the end of the trial. The final body weight of the chicks were significantly ($P<0.05$) influenced by the dietary treatments. The birds on diet 1 (control) recorded the highest final weight gain of 504.17g which was significantly ($P< 0.05$) higher than those on the test diet (375.00 - 408.33g). The average daily weight gain of the chicks at the end of the experiment

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were not significantly (p> 0.05) influenced by the dietary treatment. There was significant (P<0.05) difference in the feed consumed by birds on the different diets. The birds fed the control diet had the highest average daily feed intake (53.02g) and this decreased with increased CSRLM (95:5) mix to 51.20g. The feed efficiency values of birds fed the control diet were higher (2.02) than those fed the test diets and the values decreased (2.69-2.97) with increase in the level of inclusion of the CSRLM (95:5) mix. Table 7 shows the performance of birds (day 7-42) fed the test diets. Final body weights of birds was significantly (P<0.05) influenced by dietary treatments. The values recorded for broiler chickens fed the control diet (1970g/bird) was higher than values obtained for bird fed the test (1424 - 1660g/bird). Average daily weight gain was also significantly (P<0.05) affected by dietary treatments with the control diet recording the best (87.26g) value. No significant (P>0.05) difference was observed across dietary treatments for average daily feed intake (ADFI). Birds fed the control diet had a higher (151.43g) ADFI and this decreased (146.67 - 137.14g) with increased replacement of maize with the CSRLM (95:5) mix. The FCR for bird fed the control diets was significantly (P<0.05) better (1.74) than those fed the test diets (2.02 - 2.23).

The average weight gain of the birds did not differ significantly across the six dietary treatments. The steady decline in average weight gain of the broilers as the cassava waste replacement increased in the diet may be attributed to the concomitant reduction in feed intake with increase in the inclusion levels of cassava starch residue leaf meal (95:5) mix. The reduction in feed intake may be due to residual cyanide (0.83 - 4.14mg/kg) which is inherent in the cassava by product- based diets. Amuchie (2001) also reports that anti-nutritional factors in the diet of any livestock species may have negative effects such as reduction in palatability, digestibility and utilization of ration, intoxication of different classes of livestock, resulting in mortality or decreased production of animal and reduction in quality of meat, eggs and milk product due to the presence of hazardous residues. There was no significant difference in the feed to weight gain ratio (FCR) of chickens across the six dietary treatments. However, the progressive numerical decrease in feed conversion ratio with increase in level of inclusion of the cassava by products may be attributed to the fact that cyanide has bonded and probably complexed with some nutrients thereby obstructing nutrient absorption and complete utilization of the diets (Kayode, 2009) The highest feed to weight gain ratio was in diet 1 (2.02) while the lowest feed to weight gain ratio was observed in diet 6 (3.19) and this is consistent with the report of Adeyemo, Sani and Aderigbigbe (2013).

The FBW of the finisher birds (42 days) was depressed significantly as the replacement level of maize with cassava starch residue/cassava leaf (95:5) mix increased. This decrease in performance is attributed to poor feed utilization due to the progressive reduction of maize in the diets (Mafauo, Tegiua, Kana, Mube and Diarra 2011; Kana *et al.*, 2012, 2014). The average weight gain was significantly influenced by dietary treatments. It reduced with increase in level of inclusion of the cassava starch residue/ cassava leaf (95:5) mix in the diets. This agreed with findings of Opara, (1996) and Odunsi, Onifade and Oyewole (2010) who postulate an increase in fibre levels in diets of monogastric animal depressed weight gains. Feed intake reduced with increase in inclusion of cassava starch residues leaf meal (95.5) mix which could be due to low calorie of the test diets and reduced palatability with reduction of maize in the diet (Khajarern S. and Khajarern J. (2007). There is usually a relationship between voluntary feed intake and calorie content of animal diets. It is expected that animals should eat more of a low-energy diet in order to cancel out energy deficit (Ojewola and Longe, 1999). Therefore, it is expected that the birds on the CSRLM (95:5) mix diets should consume more than birds on the control diet. It is therefore evident that birds showed aversion to the CSRLM (95:5) diets especially at higher inclusion levels (Salami and Odunsi, 2003). This was also confirmed by Khajarern S. and Khajarern J. (2007) who state that palatability of cassava based ration is an important factor limiting feed intake of poultry. According to them, physical properties such as dustiness and bulkiness are closely related to palatability and therefore limit feed intake. This observation disagrees with the findings of Osei and Duodu (1988) and Odunsi, Onifade and Oyewole (2001), who observe increased intake of feed when cassava peel meals inclusion was increased in the diets of broilers and layers and also with finding of Onifade and Babatunde (1998); Hetland and Svihus (2001) that broilers on low energy diets attempted to adjust food intake to meet their energy requirement because among nutrients, energy concentration is the first factor affecting voluntary feed intake of chickens fed *ad libitum* (NRC, 1994).

The negative effect of high level of CSRLM (95:5) mixture on ADWG and FCR is mainly related to the high fiber content in the diets that reduced nutrient digestibility and consequently reduced growth performance and efficiency of feed utilization (Jorgenson, Zhao, Bach Knudsen and Eggum, 1996; Onifade and Babatunde, 1998). Fibrousness has also been reported by Longe and Fagbenro-Byron, (1996) as a feature of most locally available agro-industrial by-products and wastes that limit their use. Furthermore, according to Eruvbetine (1995); Stanogias and Pearce (1985) the physical bulk may affect the retention time of digest in the gastro - intestinal tract and consequently, their utilization.

CONCLUDING REMARKS

This study was conducted to evaluate the performance of broiler chickens fed with the mixture of cassava starch residue and cassava leaf in a ratio of 95:5 as a replacement for maize. A 42-day trial using 300 day old broiler chickens was conducted to evaluate the nutritive potential of cassava starch residue and cassava leaf mix on their performance characteristics. The birds were divided into 6 treatment groups and further replicated 5 times with 10 birds per replicate in a completely randomized design and fed diets containing 0, 10, 20, 30, 40 and 50% CSRLM (95:5) mix as a replacement for maize. It therefore, recommends that the replacement level of maize with cassava starch residue leaf meal (95:5) mix in the broiler starter diets should be 50% while it should be reduced to 10% in finisher diets.

Table 1: Proximate composition of Cassava starch leaf meal (95:5) mix

Basal ingredients	Dry Matter	Crude Protein	Crude Fibre	Ash	Ether Extract	Nitrogen Free Extract
Cassava starch residue leaf meal (95:5) mix	88.75±1.91	6.65±0.78^{ab}	11.14±1.44^{a}	5.11±0.01^{c}	3.22±0.03^{a}	62.63±1.41^{f}

Source: Experimentation, 2014

Table 2: Gross Composition of Experimental Diet (g/100g) for Broiler Starter fed diets in which maize was replaced with CSRLM (95:5) mix

	Level of maize replaced by CSRLM meal mix (95:5)					
Ingredients	**0**	**10**	**20**	**30**	**40**	**50**
Maize	51.19	46.07	40.95	35.83	30.71	25.60
CSRLM	0.00	5.12	10.24	15.36	20.48	25.60
SBM	30.00	28.00	26.00	22.00	19.00	20.00
GNC	9.00	11.00	13.00	17.00	20.00	19.00
FM	4.00	4.00	4.00	4.00	4.00	4.00
B/Meal	2.00	2.00	2.00	2.00	2.00	2.00
Oyster shell	0.50	0.50	0.50	0.50	0.50	0.50
Premix	0.25	0.25	0.25	0.25	0.25	0.25
Lysine	0.13	0.13	0.13	0.13	0.13	0.13
Methionine	0.13	0.13	0.13	0.13	0.13	0.13
Salt	0.30	0.30	0.30	0.30	0.30	0.30
Vegetable Oil	2.50	2.50	2.50	2.50	2.50	2.50
Total %	**100**	**100**	**100**	**100**	**100**	**100**
Calculated Analysis						
Crude Protein	23.23	23.13	23.04	23.00	22.94	22.76
M.E (Kcal/Kg)	3092.80	3042.98	2933.14	2924.10	2861.70	2843.95
Calcium % 1.54	1.42	1.34	1.24	1.24	1.20	
Available Phosphorus %	0.61	0.59	0.58	0.56	0.55	0.55

Source: Experimentation, 2014

Table 3: Proximate Composition of the Experiment Diets (g/100g) for broiler- starter fed diets in which maize was replaced with CSRLM (95:5) mix

Diet	**% Maize replaced by CSRLM (95:5) mix**	**Dry Matter**	**Crude Protein**	**Crude Fibre**	**Ether Extract**	**ASH**	**NFE**
1	0	89.79±1.19	23.20±4.20	4.53±0.10^{a}	3.862±2.05	6.95±2.18	51.25±4.45
2	10	88.49±1.22	23.31±1.48	5.27±0.07^{ab}	2.89±0.27	7.01±0.24	50.01±0.00
3	20	88.56±2.94	22.89±0.44	5.32±0.96^{ab}	2.82±0.28	7.4±0.20	50.13±0.18
4	30	88.97±2.86	22.86±0.11	6.01±0.01^{bc}	2.53±0.99	7.6±0.20	49.97±0.61
5	40	89.44±4.00	22.76±0.57	6.54±0.68^{bc}	2.42±0.14	7.8±0.02	49.84±0.14
6	50	89.56±0.17	22.62±2.97	7.02±0.27^{c}	2.32±0.01	8.1±0.47	49.50±0.28

CSRLM = Cassava starch residue leaf meal, NFE = Nitrogen free extract

Source: Experimentation, 2014

Table 4: Gross Composition of Experimental diet (g/100g) for broiler finisher fed diets in which maize was replaced with CSRLM (95:5) mix

	Level of maize replaced by CSRLM (95:5) mix					
Ingredients	**0**	**10**	**20**	**30**	**40**	**50**
Maize	58.23	52.41	46.58	40.76	34.94	29.12
CSRLM	0.00	5.82	11.65	17.47	23.29	29.12
SBM	24.00	24.00	24.00	24.00	24.00	16.00
GNC	9.00	9.00	9.00	9.00	9.00	17.00
FM	3.50	3.50	3.50	3.50	3.50	3.50
B/Meal	2.00	2.00	2.00	2.00	2.00	2.00
Oyster shell	0.50	0.50	0.50	0.50	0.50	0.50
Premix	0.25	0.25	0.25	0.25	0.25	0.25
Lysine	0.11	0.11	0.11	0.11	0.11	0.11
Methionine	0.11	0.11	0.11	0.11	0.11	0.11
Salt	0.30	0.30	0.30	0.30	0.30	0.30
Vegetable Oil	2.00	2.00	2.00	2.00	2.00	2.00
Total %	**100**	**100**	**100**	**100**	**100**	**100**

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Calculated Analysis						
Crude Protein %	20.21	20.03	19.86	19.68	19.51	19.50
M.E (Kcal/Kg)	3109.20	3053.88	2898.49	2843.20	2787.90	2728.06
Calcium	1.44	1.40	1.24	1.22	1.22	1.20
Phosphorus	0.57	0.56	0.56	0.55	0.55	0.51

CSRLM =Cassava starch residue leaf meal, SBM =Soybean Meal, GNC = Groundnut Cake, FM =Fishmeal, B/meal = Bone meal.

Source: Experimentation, 2014

Table 5: Proximate Composition of the Experiment diets (g/100g) for broiler- finisher fed diets in which maize was replaced with CSRLM (95:5) mix

Diet	% Maize replaced by CSRLM (95:5) mix	Dry Matter	Crude protein	Crude Fibre	Ether Extract	ASH	NFE
1	0	88.92±2.23	20.26±1.84	3.6±1.84^{a}	3.92±2.23	7.82±2.23	53.32±0.42
2	10	89.13±0.03	20.04±1.30	6.03±0.01^{b}	2.63±0.55	8.25±0.07	52.18±1.53
3	20	89.56±0.80	19.78±0.03	6.30±0.40^{b}	2.60±0.08	8.42±0.82	52.19±2.82
4	30	89.47±0.10	19.53±0.83	6.46±0.06^{b}	2.50±0.74	8.62±0.75	52.36±0.23
5	40	88.83±0.27	19.42±0.28	7.26±0.06^{b}	2.48±0.62	8.93±1.29	50.74±1.27
6	50	88.05±0.01	19.40±0.99	7.55±0.78^{b}	2.40±0.14	9.02±0.01	49.68±1.47

CSRLM = Cassava starch residue leaf meal, NFE = Nitrogen free extract

Source: Experimentation, 2014

Table 6: Performance characteristics of broiler chickens fed CSRLM (95:5) mix in place of maize (age 7-21)

Parameter	Diet 1	Diet 2	Diet3	Diet 4	Diet 5	Diet 6	±SEM
	Maize replacement with CSRLM (95:5) mix						
	0%	10%	20%	30%	40%	50%	
Initial live weight (g/bird)	137.50	133.33	133.33	133.33	137.50	133.33	0.02
Final body weight (g/bird)	504.17^{a}	408.33^{b}	404.17^{b}	380.00^{b}	379.17^{b}	375.17^{b}	11.49
Total weight gain (g/bird)	366.67^{a}	275.00^{b}	270.84^{b}	246.67^{b}	241.67^{b}	241.67^{b}	22.53
Average daily weight gain (g/bird/day)	26.19	19.64	19.35	17.62	17.26	17.26	1.86
Total feed intake (g/bird)	742.25^{a}	740.32^{a}	735.42^{ab}	728.28^{b}	720.30^{bc}	716.80^{c}	19.54
Average daily feed intake (g/bird/day)	53.02	52.88	52.53	52.02	51.45	51.20	0.61
Feed conversion ratio	2.02	2.69	2.72	2.95	2.98	2.97	0.23

a, b, c: Mean within rows having different superscripts are significantly different (P<0.005)

Source: Experimentation, 2014

Table 7: Performance characteristics of broiler chickens fed CSRLM (95:5) mix n place of maize (age 1-42)

Parameter	Diet 1	Diet 2	Diet3	Diet 4	Diet 5	Diet 6	±SEM
	Maize replacement with CSRLM (95:5) mix						
	0%	10%	20%	30%	40%	50%	
Initial live weight (g/bird)	137.50	133.33	133.33	133.33	137.50	133.33	0.02
Final body weight (kg/bird)	1.97^{a}	1.66^{b}	1.74^{bc}	1.56^{cd}	1.44^{de}	1.42^{e}	0.05
Total weight gain (kg/bird)	1.83^{a}	1.53^{b}	1.43^{bc}	1.40^{cd}	1.30^{de}	1.29^{e}	0.05
Average daily weight gain (g/bird/day)	87.26^{a}	72.70^{b}	67.94^{bc}	66.79^{cd}	62.02^{de}	61.46^{e}	2.19
Total feed intake (kg/bird)	3.18	3.08	3.06	3.00	2.98	2.88	0.05
Average daily feed intake (g/bird/day)	151.43	146.67	145.71	142.67	141.71	137.14	2.21
Feed conversion ratio	1.74^{a}	2.02^{b}	2.14^{b}	2.14^{b}	2.28^{b}	2.23^{b}	0.05

a, b, c: Mean within rows having different superscripts are significantly different (P<0.005)

Maize replacement with CSRLM (95:5) mix

Source: Experimentation, 2014

REFERENCES

Adeyemo I. A. Sani A. and **Aderigbigbe T. A.** (2013). Growth performance and nutrient retention of broiler chickens fed Aspergillusnigerhydrolysed cassava peel based diet. *American Journal of Research communication,* 1(7), 294-306.

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Amuchie E. C. (Jnr) (2001). Anti-nutritional factor in feeds and their effects on Livestock production seminar presented to the Dept of Animal Production, University of Agriculture Makurdi (unpublished).

Duncan, D. B. (1955). Multiple Range and Multiple F-Tests. *Biometrics*, 11, 1-14.

Erubevtine, N. (1995). Processing and utilization of cassava as animal feed for non-ruminant animal. Paper presented at the workshop on Alternative feed stuff for livestock organized by the Lagos state ministry of Agriculture and co-operation and rural Development, Lagos, Nigeria.

Eruvbetine D., Tajudeen I. D., Adeosun A. T. and **Olojede A. A.** (2003). Cassava (manihotesculenta). Leaf and tuber concentrate in diets for broiler chickens. *Bioresource Technology*, 86, 277-281.

Hetland, H. and **Svihus, B.** (2001). Effect of Oat hulls on performance, gut capacity and feed passage time in broiler chickens. *British Poultry Science,* 42, 354-361.

Jorgenson H. H., Zhao X. X. Q., Bach Knudsen K. E. and **Eggum B. B. O.** (1996). The influence of dietary fiber source and level on the development of the gastro- intestinal tract, digestibility and energy metabolism in broiler chickens. *The British Journal of Nutrition,* 75, 379-395.

Kana J. R,, Defang Fulefak H., Mafouo Gandjou H., Ngouana T. R., Moube Noubisse, Ninjo J. and **Teguia A.** (2012). Effect of cassava meal supplemented with a combination of Palm oil and cocoa husk as alternative energy source on broiler growth. *Archive of Zoo technical,* 15, 17-25.

Kana J. R., Tadjong R. N., Kiuietche H. M., Terfack Y., Zambou H. and **E. T. Tequia A.** (2014). Valorisation des residus de manioc en substitution du maisdan la ration alimentaire du poulet de chair. *Livestock Research for Rural Development* Vol.26, Article #48 from *http:/ www.Irrd.org/Irrd26/3/kana26048.htm.* Retrieved February 26, 2014.

Kayode, R. M. (2009). Suitability of mango (mangiferaindicus) fermented kernel as animal feed supplement Ph.D. Thesis University of Ilorin, Nigeria.

Khajarern, S. and **Khajarern, J. M.** (2007). Use of cassava products in Poultry feeding *www.fao.org/docrep/003/TOSS4E/TO554E 10.htlm.*

Longe, O. H. and **Fagbenro- Byron, U.** (1996). Composition and some physical characteristic or some fibrous wastes by products for pig feeding Nigeria Bietr. Trop. London vet med. 28:199-205.

Mafauo N. H., Tegiua A., Kana J. R., Mube H. K. E. T. and **Diarra M.** (2011). Effect du niveaud'incorporation de la farine de manioc dans la ratio sur les performances de croissance des poulet de chair. *Livestock Research for Rural Developmemt,* Vol. 23, Article #76.

NRC (1994). Nutrient Requirement of Poultry. In the nutrients requirement of farm animal (National Academy of Science) 9th revised ed.

Obih T. K. O., Ekenyem B. U. and Nwangwu U. M. (2010). Cassava Peels meal as substitute for whole maize on the performance of broiler finisher chicks. *Animal production Research Advances,* 6 (3), 197-200

Odunsi A. A., Onifade A. M. and **Oyewole S. O.** (2001). Utilization of cassava peel meal with or without sheabutter fat in diets of egg-type chicken. *Indian Journal of Animal Science* (Accepted).

Ojewola G. S. and **Longe, O. G.** (1999). Protein and energy in broiler Starter diets. Effect on growth performance and nutrient utilization. *Nigerian Journal of Animal Products*, 26, 23-28.

Omole, T. A. (1977). *Cassava in the nutrition of layers*. In B. Nestel, and M Graham (eds) *Cassava as Animal Feed.* London: International Development Research Centre. pp. 51-55.

Onifade, A. A. and **Babatunde, G.. M.** (1998). Comparison of the utilization of palm kernel meal, Brewer dried grains and Maize offal by broiler chicken. *British Poultry Science,* 39, 2, 245-264.

Opara, C. C. (1996). Studies on the use of Alchorneacordifolia leaf meal as feed ingredient in poultry diets. An MS. C. Thesis submitted to Federal University of Technology, Owerri, Nigeria.

Osei, S. A. and **Duodu, S.** (1988). Effect of fermented cassava peel meal on the performance of broiler. *British Poultry Science*, 29 (3), 671-675.

Salami R. F. and **Odunsi, A. A.** (2003). Evaluation of processed cassava peel meals as substitutes for maize in the Diets of Layers. *International Journal of Poultry Science,* 2(2), 112-116.

Stanogias, G. and **Pearce, G. R.** (1985). The digestion of fibre by pigs 1 the effect of amount and type of fibre on apparent digestibility nitrogen balance and rate or Passage. Br. 53, 513-530.

Steel R. D. G. and **Torrie, J. H.** (1960). *Principles and Procedures of Statistics* (1st edn) New York: McGraw Hill.

Wyllie, D. (1979). Systems of cassava forage production for the semi-arid. *Tropical Animal Production* 4, 95 (Abstracts).

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