Can avocado meal replace maize meal in broiler diets?

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Abstract

After the oil has been extracted from avocado fruits that were unsuitable for the fresh fruit market, a product, avocado meal (AM), remains as a waste product, and this product is causing a disposal problem for fruit distributers. An investigation was conducted to establish if AM could be used as a feed ingredient for livestock. In this study, AM substituted 0%, 10%, 20%, 30% and 40% of the maize which constituted 68% and 75% of a broiler diet at the different feeding stages. On average AM constituted 0%, 7.3%, 14.7%, 22.0% and 29.3% of the total diet in the respective treatments. At two weeks of age 400 broilers were allocated to the five treatments, each treatment consisting of four replications of 20 birds. As the level of AM in the diet increased, feed intake, average daily gain and feed conversion efficiency (FCE, g weight/kg feed) decreased linearly (significantly). At 42 days of age (28 days on the experimental diets) the final weight and FCE of the birds on the 0% AM diet were 1987 g and 517, respectively, compared to 1001 g and 273 on the 29.3% AM diet. It was concluded that antinutritional substances in AM such as high levels of condensed tannin and crude fibre probably contributed to the poor performance of the birds. Though not tested in the trial, the toxicant, persin, that is present in some varieties of avocado plants, might have contributed to the poor performance. Further investigations are required to establish the cause(s) of the poor performance of the broilers consuming AM, and whether it can be overcome and treated or not. However, from the current study it is concluded that AM is not suitable as a feed ingredient in poultry diets.

Keywords: Anti-nutritional factors, condensed tannin, crude fibre, *Persea americana*, persin
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Introduction

Numerous studies have shown that many novel, unconventional feedstuffs including agricultural by- and waste products can serve as viable alternatives to traditional ingredients of poultry diets (Wilkinson 1988; Ensminger *et al*., 1990; Álvarez-Fuentes *et al*., 2012). One objective of such studies is to identify feedstuffs that are not directly utilized by humans to avoid competition between humans and livestock for food sources (Ani & Okorie, 2005; Magoda & Gous, 2011). Another important incentive is to find ways of utilizing agricultural waste products and residues. These products tend to accumulate with the concomitant cost of disposing of them, and managing them to limit environmental pollution (Dierick & Decuypere, 1996; Bampidis & Robinson, 2006).

However, these products frequently contain anti-nutritional components such as condensed tannins, saponins (D'Mello, 2000; Magoda & Gous, 2011) and non-starch polysaccharides which most monogastric livestock are incapable of digesting (Dierick & Decuypere, 1996). In addition, these products might contain toxic substances such as cyanogenic glycoside in cassava (Oke, 1978; Gomez *et al*., 1984).

In the avocado *(Persea americana)* fresh fruit industry, avocado meal is a waste product consisting of oil-extracted avocado fruits that were unsuitable for the fruit market. The residue is considered a waste product that creates a disposal problem. From the chemical composition of the product it seems to be a potential feedstuff for animals, specifically as an energy source (Skenjana, 2011). Skenjana *et al*. (2006) performed *in vitro* organic matter digestibility (IVOMD) and *in situ* dry matter (DM) disappearance studies with sheep, and observed a relatively high DM degradation of 67.1% in the rumen, and an IVOMD of 54.3%. This suggests that the product might be suitable as a feed ingredient in ruminant diets. Skenjana *et al*. (2006) also recorded a relatively high concentration of condensed tannin of 143.1 g/kg in avocado meal.

However, the nature of these small sample laboratory tests (Skenjana *et al*., 2006) did not investigate or would reveal the fact that the plant components of many varieties of the avocado plant contain a toxin, persin (Kellerman *et al*., 2005). Burger *et al*. (1994) reported intoxication of ostriches grazing lucerne and

weeds in an avocado orchard, and Buoro *et al*. (1994) reported that two dogs that developed a taste for the avocado fruit, developed toxicity symptoms and died. Burger *et al.* (1994) investigated this further, using ostriches and laying hens. Microscopical examinations revealed signs of toxicity in both species though Hargis *et al*. (1989) reported that different species of caged birds seem to differ in ability to tolerate the toxin in avocados.

An investigation was conducted to ascertain to what extent AM can be used as an ingredient in the diet of broiler chickens.

Material and Methods

The study was conducted with the approval of the Ethics Committee of the Faculty of Natural and Agricultural Sciences of the University of Pretoria. Dried avocado meal with the oil partially extracted was obtained from the Da Gama oil factory, Nelspruit, South Africa. The waste product derived from the oil extraction of lower grade avocados that were not suitable for the commercial fruit market. The fruit is ripened, crushed as is (seed, peel and flesh) and mixed with hot water. It is pumped into a mixing tank where retention time allows the oil cells to break. The product left is put through a kiln dryer (70 ºC) to remove moisture. The chemical composition of the avocado meal used in the study is presented in Table 1. The analytical methods as described by the AOAC (2000) were used to measure the nutrient content of the avocado meal.

Table 1 The chemical composition of the avocado meal (g/kg DM) used in the study and the average chemical composition of maize meal (CVB, 2007)

Nutrient	Avocado meal	Maize meal
Dry matter	949	872
Crude protein	156	82
Crude fat	63	38
Crude fibre	349	22
Calcium	2.0	.02
Total phosphorus	2.0	2.7
[1]Lysine	2.4	-

[1] Mean from Skenjana *et al.* (2006).

Table 2 Ingredients in the broiler diets, containing different percentages of avocado meal (AM) replacing maize meal

Ingredients	Treatments: % avocado meal (AM) replacing maize meal				
	0%	10%	20%	30%	40%
Starter diets					
Yellow maize (%)	68.0	61.2	54.4	47.6	40.8
Commercial protein conc. (%)	32.0	32.0	32.0	32.0	32.0
% AM in starter diet	00.0	6.8	13.6	20.4	27.2
Finisher diets					
Yellow maize (%)	75	67.5	60.0	52.5	45.0
Commercial protein conc. (%)	25	25.0	25.0	25.0	25.0
% AM in finisher diet	0	7.5	15.0	22.5	30.0
AM in total diet over experimental period[1] (%)	0	7.3	14.7	22.0	29.3

[1] Calculated weighted mean.

Four hundred day-old unsexed Ross 308 broiler chickens were purchased from National Chicks, Pretoria, South Africa. At 14 days of age the chickens were randomly assigned to five treatment groups with a total of 80 chickens per treatment, divided into four replications of 20 birds per replication. Five treatment diets were formulated in which avocado meal replaced 0%, 10%, 20%, 30% and 40% of the maize meal in a commercial broiler diet. Commercial starter and finisher protein concentrates for broilers (Farmix Broiler Starter and Finisher) were obtained from Epol (Pty, LTD) South Africa, to which prescribed amounts of maize meal were added (Table 2).

The avocado meal constituted 0%, 7.3%, 14.7%, 22.0% and 29.3% of the total diet. The calculated chemical composition of the treatment diets is presented in Table 3.

Table 3 Calculated chemical composition of starter and finisher experimental diets (g/kg)

Diets % AM[1]	Crude protein		Ether extract		Crude fibre		Calcium		Total P	
	St	Fn	St	Fn	St	Fn	St	Fn	St	Fn
0	229	191	32	34	43	38	12	12	7	6.4
7.3	233	195	33	35	63	61	12	12	7	6.4
14.7	236	199	34	37	84	84	12	13	7	6.3
22.0	240	202	35	38	105	107	13	13	7	6.3
29.3	243	206	36	39	126	130	13	13	7	6.3

St: starter diet (days 15 - 21); Fn: finisher diet (days 22 - 42).
[1] % avocado meal (AM) in the total diet. Total P: total phosphorus.

The study was conducted in an environmentally controlled broiler house on the experimental farm of the University of Pretoria, Pretoria, South Africa. The replicate groups of chickens were placed randomly in pens (3 x 1.5 m) enclosed with chicken mesh, and sawdust was used as litter material. The chickens were fed a commercial starter for the first two weeks to provide a good start and the experimental diets for a further 28 days; for the first 7 days the starter and the following 21 days the finisher diet. Feed and water were provided *ad libitum*. Light was provided for 24 h per day and infrared bulbs were used to supply heat. Room temperature was decreased from 32 °C during the early stages to 22 °C from day 21 onwards. The chickens were vaccinated according to the standard vaccination programme for the experimental site.

Body weight of the birds and feed intake per pen were recorded once a week. Feed conversion efficiency (FCE) was calculated as body weight (in g) per pen over feed intake (in kg). Mortalities were recorded.

An analysis of variance with the ANOVA model (SAS, 1994) was used to determine significance differences between treatment means. A significance difference of 5% between means was determined using the Bonferroni t-test. Repeated measures ANOVA was conducted on weekly body weights as contrast variables. Regression analysis on the feed intake and final mass of broilers was done, using SAS (1994).

Results and Discussion

All measurements related to the performance of the birds, viz. average daily gain, feed intake, final weight and FCE showed a continuous decrease (P <0.05) as the level of avocado meal increased in the diet. This is clearly demonstrated in the negative regressions for feed intake (Equation 1) and final weight (Equation 2) of the birds. For every percentage that avocado meal replaced maize in the diet, there was a linear decline of 0.74 g in feed intake and a 25.9 g lower final weight in the broilers.

$$y = -0.74x + 116.42 \qquad R^2 = 0.99 \qquad (1)$$

x = level of avocado meal; y = mean daily feed intake

$y = -25.94x + 1989.56$ $R^2 = 0.99$ (2)
x = level of avocado meal; y = final weight

The performance of broilers on the commercial diet containing different levels of avocado meal that replaced maize meal is presented in Table 4.

Table 4 Effects of including different levels of avocado meal in a commercial broiler diet on the performance of broilers

	Treatments: % avocado meal in total diet					**SEM**
	0%	**7.3%**	**14.7%**	**22.0%**	**29.3%**	
Initial weight (g)	308	327	317	343	316	21.1
Mean feed intake/d (g)	116[a]	110[ab]	101[b]	93[bc]	88[cd]	3.3
Final weight (g)	1987[a]	1742[b]	1510[c]	1199[d]	1001[e]	39.5
Average daily gain (g)	60[a]	51[b]	42[c]	31[d]	24[e]	1.41
FCE (g gain/kg feed)	517[a]	464[b]	416[b]	333[c]	273[d]	0.008

[a,b,c,d,e] Row means with the same superscript do not differ significantly ($P > 0.05$).
FCE: feed conversion efficiency; SEM: standard error of the mean.

From the chemical compositions presented in Tables 1 and 3 it is obvious that AM is not a substitute for maize meal, especially because of the higher crude fibre levels in AM compared to maize meal. Furthermore, Skenjana (2011) reported that AM (n = 8) contains 258 ± 86.4 mg condensed tannin/kg DM, an antinutritional substance in poultry diets. It can be concluded that the increase in the crude fibre (Tables 3) and condensed tannin contents with an increase in avocado meal in the diets would probably have contributed to the decline in feed intake and thus performance of the birds.

No mortalities occurred during the experiment phase of the study, nor did any of the birds display physical signs of discomfort. Since histopathological evaluations were not performed on the birds, it was not possible to establish to what extent chronic persin toxicity could have contributed to the poor performance of the birds consuming avocado meal. Burger *et al.* (1994) recorded myocardial lesions in laying hens one week after dosing an "avocado plant material suspension" consisting of fresh leaves and young fruit. Unfortunately published investigations and the case reports are not comparable with the situation in the present study. It seems as if fresh components of the avocado plant was used in all the studies, while in the present study the avocado meal was heat-treated and dried. In many products containing toxic substances, the drying process which often includes heat treatment was found to destroy the toxicant, for example the cyanogenic glycoside in cassava (Gomez *et al*., 1984), or trypsin inhibitor in soybeans (Polliyeguru *et al*., 2011). In some of the reports in the literature, avocado leaves were fed to goats (Grant *et al*., 1991) or fresh leaves and young fruit (Burger *et al*., 1994). Furthermore, it is well documented that different varieties of avocado differ in degree of toxicity (Kellerman *et al.*, 2005). It can be assumed that avocado meal as used in the current study might contain varying combinations of avocado varieties, and that the degree of toxicity would probably vary from batch to batch.

According to the literature, toxicity symptoms due to persin are fairly acute and dramatic, and are manifested within a few days after consumption (Hargis *et al*., 1989; Buoro *et al*., 1994). However, in most of these studies not enough information has been supplied to calculate the avocado DM intake of the animals. Calculated from the information supplied by Hargis *et al*. (1989), at the highest levels of application, budgerigars were dosed *ca*. 7% and 14% of their body weight in avocado (estimated DM content, 15%) over a period in one day, and died within 47 h. These seem to be massive doses that were followed by acute toxicity symptoms. In the present study the broilers in the 40% avocado treatment received

over the experimental period of 28 days a daily dose of avocado meal constituting *ca*. 3.8% of their body weight, and displayed no physical symptoms of toxicosis, suggesting that the toxicity, if present, might have been more of a chronic nature.

Conclusion

Apart from reduced performance no clear toxicity symptoms were observed in the broilers when consuming the avocado meal, even after six weeks of receiving a diet containing 29% avocado meal. Anti-nutritional factors were present in the diet, and would have contributed to the poor performance of the birds. However, further studies are required to establish the cause(s) of the poor performance of broilers consuming AB and whether it can be rectified. Therefore, based on the present evidence AM cannot be recommended for inclusion in broiler diets.

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