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Effect of cottonseed oilcake inclusion on ostrich growth performance and meat chemical composition

A. Dalle Zotte [a,*], T.S. Brand [b,c], L.C. Hoffman [c], K. Schoon [c], M. Cullere [a], R. Swart [b]

[a] Department of Animal Medicine, Production and Health, University of Padova, Agripolis, Viale dell'Università, 16, 35020 Legnaro (PD), Italy
[b] Elsenburg Institute for Animal Production, Western Cape, Department of Agriculture, Private Bag XI, Elsenburg 7606, South Africa
[c] Department of Animal Sciences, University of Stellenbosch, Western Cape, Stellenbosch, 7602, South Africa

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ABSTRACT

This study investigated the effect of replacing dietary soybean oilcake meal with increasing levels of cottonseed oilcake meal (CSOCM) on the growth performance and meat (*Iliofibularis* muscle) chemical composition of ostriches in order to decrease total feed costs. A total of 105 ostriches were divided into five feeding groups according to the CSOCM inclusion level in the whole diet: Control (0% CSOCM), 3%, 6%, 9% and 12% CSOCM (of the whole diet), and fed with experimental diets from 6 to 13 months of age. As a result of feeding CSOCM, the final live weight and the average daily gain significantly increased in the 12% CSOCM group. The proximate composition, cholesterol content, mineral and fatty acid profile of the meat remained unaffected. Thus CSOCM may be used as an alternative protein source to the more expensive soybean oilcake meal in ostrich nutrition.

1. Introduction

Ostrich (*Struthio camelus* var. *domesticus*) farming as a commercial enterprise began in South Africa between 1857 and 1864 (Smit, 1963) and has made a major contributor to the agricultural economy of South Africa for the last 150 years (Brand & Cloete, 2009). Although ostriches were originally domesticated for the harvesting of their feathers, which was followed by high prices being paid for their skins, nowadays they are farmed to provide a healthy red meat (Cooper & Horbańczuk, 2002). As stated in many studies (Sales & Hayes, 1996; Sales et al., 1999), ostrich meat has high PUFA content, low total fat, low sodium content, and is rich in heme-iron, and for these reasons can be considered a healthy red meat to be appreciated by modern consumers.

The ostrich is mainly herbivorous and, in natural conditions, its diet consists of a variety of plants and succulents (Jamroz, 2000). However, Nitzan, Barkai, Nitsan, and Landau (2002) noticed that under grazing conditions, ostriches prefer forb-type pastures, and alfalfa, for example (Strydom, Brand, Aucamp, & van Heerden, 2009), to grasses. In South Africa, ostriches are reared mainly under intensive feedlot (80%) or semi-intensive grazing (20%) conditions (Brand & Gous, 2006), and therefore most of the nutrition is provided by formulated feeds and concentrates. In feedlots, feed should be supplied *ad libitum* with clean water available at all times in order to aid digestion because ostriches need to feed continuously rather than in separate time slots (Aganga, Aganga, & Omphile, 2003). The successful rearing of ostriches from hatching to grower to breeder birds requires high standards of nutrition (Cooper, Horbańczuk, & Fujihara, 2004) and because nutrition accounts for nearly 80% of total ostrich production costs (Brand & Olivier, 2011), more knowledge on this topic is required. The protein source represents a large part of these costs, and therefore the discovery of alternatives at lower prices that do not affect ostrich growth performance and are preferably not used in human nutrition would be beneficial for the industry and farmers alike.

Cottonseed oilcake, a textile industry by-product, offers an alternative to the commonly-used but more expensive soybean. The main problem that has limited its utilization in animal nutrition thus far is the presence of gossypol, a toxic polyphenol naturally found in the pigment glands of the cottonseed. Gossypol is a reactive compound that rapidly binds minerals and amino acids when it is in its free form (Guedes & Soto-Blanco, 2010). Gossypol content varies between species of cotton plant and also depends on differences in cottonseed processing that change its concentration (Kakani, Gamboa, Calhoun, Haq, & Bailey, 2010; Nagalakshmi, Rao, Panda, & Sastry, 2007; Schroeder, Erasmus, Leeuw, & Meissner, 1995); moreover, animal species react differently to this particular polyphenol. For all these reasons, scientific studies concerning its utilization in animal nutrition, especially monogastrics, have provided controversial results (Fombad & Bryant, 2004; Ikurior & Fetuga, 1988; Nunes, De Araújo, Bezerra, & Soto-Blanco, 2010; Rhule, 1995; Wanapat et al., 2012; Winterholler, Lalman, Hudson, & Goad, 2009). Although Aganga et al. (2003) stated that gossypol has also been shown to

* Corresponding author.
E-mail address: Antonella.dallezotte@unipd.it (A. Dalle Zotte).

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have toxic effects on ostriches, no studies on the effect of cottonseed oilcake meal (CSOCM) on the production and meat quality of ostrich meat have been conducted.

This study aimed to establish whether and to what extent the gradual replacement of soybean oilcake meal with CSOCM could affect ostrich growth performance and meat quality. The aim therefore also included verifying whether CSOCM might be considered a viable alternative protein source in ostrich feeding or not.

2. Materials and methods

2.1. Experimental design and diets

2.1.1. Birds, management, slaughter and meat sampling

A total of 105 ostriches (*Struthio camelus* var. *domesticus*) were used to study the effect of the inclusion of cottonseed oilcake on growth performance and meat (*Iliofibularis*, or fan fillet, muscle) chemical composition of ostriches from 6 to 13 months of age. Hatching and rearing of the 105 ostriches took place on Kwessie farm, in Calitzdorp, South Africa. Ostriches remained on this farm until 6 months of age before being transported to the Kromme Rhee experimental farm outside Stellenbosch, South Africa, where they were kept for the duration of the trial (7 months; March to October). The birds were divided into five groups containing both sexes, however, as it is not possible to sex birds at this young age, the genders were not balanced. Ostriches were then subdivided into three replicate pens, resulting in 15 different paddocks (approx. 200 m^2/bird) and fed five experimental diets (Tables 1 and 2) *ad libitum* with free access to drinking water. Diets were formulated on an isonitrogenous and isoenergetic basis allowing for the gradual replacement of soybean oilcake meal (SBOCM) with cottonseed oilcake meal (0% CSOCM/Control, 3% CSOCM, 6% CSOCM, 9% CSOCM and 12% CSOCM of the whole diet) (Table 1). CSOCM used in this study had 30.9% crude protein, 0.6% crude fat, 26.2% crude fiber and 9.1% moisture, respectively. Body weights were recorded individually on a monthly basis for the 7 month duration of the trial. Feed intake was also determined per month for each of the replicates. Therefore, feed conversion rate (FCR) as well as average daily gain (ADG) were determined as an average for the replicate. During the trial, 5 animals died: 2 in the Control group, 1 in the 3%, 1 in the 6%, and 1 in the 12% CSOCM groups. Birds were kept in roofed pens for two weeks prior to slaughter so as to undergo the mandatory blood tests for avian influenza. During this period they still received their standard experimental diets.

Slaughtering of ostriches took place at Ostriswell, a commercial abattoir in Swellendam, South Africa, using standard procedures as described by Hoffman (2012). The birds were transported for 4 h and stood in lairage overnight where they had access to drinking water but no feed. Electrical head stunning (90–110 V, 400–600 mA, 4–6 s) was applied. After stunning the ostriches were suspended by both legs and exsanguinated by a neck cut to the aortic vein (thoracic stick). Bleeding was allowed for 10–15 min followed by plucking, skinning, evisceration and a health inspection. Carcasses were chilled for 24 h at 0–4 °C, after which the fan fillet (*Iliofibularis* muscle) was excised for chemical analysis. Meat samples were vacuum packed and frozen at −20 °C until further analyses were completed.

Proximate composition (of both feed and meat samples), fiber fractions and gross energy (GE, MJ/kg) of the diets were analyzed at Stellenbosch University, South Africa, whereas Ca and P of the diets were analyzed at the Elsenburg Institute for Animal production, Stellenbosch.

Free, bound and total gossypol content in the CSOCM raw material and free gossypol content in the experimental diets were measured at CENTROLAB$_{cc}$, Durbanville, South Africa. The fatty acid (FA) profile of the experimental diets and the meat, iron content of the diets as well as the mineral and cholesterol content of the meat were analyzed at the Animal Medicine, Production and Health (MAPS) Department of the University of Padova, Italy. Meat samples were freeze-dried before transportation.

2.1.2. Chemical analysis of feed samples

The finely ground feed samples were analyzed to determine dry matter (934.01), ash (967.05) and crude protein (2001.11) content according to AOAC (2002) methods. Ether extract was determined using ether extraction with diethyl ether reagent (AOAC, 2002, procedure 920.39). Crude fiber was analyzed according to AOAC (2002), procedure 962.09. Acid Detergent Fiber (ADF) and Neutral Detergent

Table 1
Chemical composition, mineral and free gossypol content of the cottonseed oilcake meal (CSOCM) and the experimental diets (g/100 g as fed).

	CSOCM	Experimental diets				
		Control	CSOCM 3%	CSOCM 6%	CSOCM 9%	CSOCM 12%
DM	91.9	89.8	89.9	88.7	89.1	89.7
Crude protein	30.9	17.3	16.3	16.2	15.7	16.0
Crude fat	0.60	2.74	2.84	2.87	2.83	3.04
Crude fiber	26.2	12.6	13.1	11.8	12.3	12.8
Ash	6.03	11.2	10.6	9.63	10.1	10.6
NDF	49.2	21.4	23.3	22.3	23.4	26.0
ADF	33.4	15.7	16.3	15.1	15.4	16.6
Ca	0.24	2.69	2.44	2.14	2.36	2.37
P	0.79	0.62	0.63	0.64	0.67	0.75
Fe	0.024	0.037	0.039	0.037	0.039	0.036
GE[a] (MJ/kg)		15.35	15.35	15.30	15.23	15.33
ME[b] (MJ/kg)		11.32	11.32	11.32	11.32	11.32
Free gossypol (ppm)	82	ND[c]	ND[c]	ND[c]	10–20	10–20

[a] Gross energy.
[b] Metabolisable energy.
[c] Not Detected, chemical analysis performed in triplicate.

Table 2
Fatty acid profile of raw materials and of experimental diets (% of total identified FAME).

	Experimental diets				
	Control	CSOCM 3%	CSOCM 6%	CSOCM 9%	CSOCM 12%
C10:0	0.10	0.06	0.05	0.02	0.03
C12:0	0.23	0.20	0.15	0.10	0.14
C14:0	0.68	0.48	0.42	0.40	0.46
C15:0	0.30	0.20	0.14	0.13	0.14
C16:0	23.3	24.5	20.8	22.0	24.3
C17:0	0.31	0.28	0.22	0.21	0.22
C18:0	7.00	4.01	3.48	3.08	3.85
C20:0	0.45	0.74	0.58	0.51	0.58
C22:0	0.00	0.00	0.00	0.00	0.00
C23:0	0.00	0.14	0.12	0.07	0.11
Total SFA	32.4	30.6	25.9	26.5	29.9
C14:1	0.04	0.04	0.05	0.02	0.00
C15:1	0.00	0.00	0.00	0.00	0.00
C16:1	2.94	0.49	0.35	0.31	0.32
C17:1	0.28	0.09	0.08	0.08	0.08
C18:1*n*-9ct	24.8	23.6	26.2	20.9	24.8
C18:1*n*-11t	2.04	1.13	0.87	0.99	0.89
C20:1*n*-9	0.11	0.10	0.09	0.11	0.11
C22:1*n*-9	0.55	0.15	0.31	0.16	0.32
Total MUFA	30.8	25.6	27.9	22.5	26.5
C18:2*n*-6ct	25.4	31.5	34.7	40.4	31.7
C18:3*n*-6	0.04	0.03	0.02	0.06	0.01
C18:3*n*-3	3.16	3.62	3.92	3.42	3.94
C18:2c9t11	0.06	0.11	0.12	0.11	0.13
C20:2	0.06	0.10	0.11	0.11	0.13
C20:3*n*-6	0.07	0.07	0.05	0.06	0.06
C20:4*n*-6	0.56	0.11	0.06	0.05	0.04
C20:3*n*-3	0.00	0.01	0.00	0.00	0.00
C20:5*n*-3	0.41	0.49	0.64	0.53	0.49
C22:6*n*-3	0.00	0.00	0.00	0.00	0.00
Total PUFA	29.7	36.0	39.6	44.8	36.5
n-6	26.0	31.7	34.9	40.6	31.8
n-3	3.57	4.12	4.56	3.95	4.43
n-6/*n*-3	7.29	7.70	7.64	10.30	7.17
UFA/SFA	1.87	2.01	2.61	2.54	2.11
MUFA/PUFA	1.04	0.71	0.70	0.50	0.73