Sahel J. Vet. Sci. Vol. 6, No. 1, pp. 19 - 25 (2007)

1605-8954/07/$25.00 + 00

Sahel Journal of
Veterinary Science

Carcass Characteristics of Broilers Fed Differently Processed Sesame (*Sesamum indicum*) Seed as a Source of Dietary Methionine

S. S. Diarra*[1], E. O. Oyawoye[2], I. Tahir[2]. and A. Yisa[3]

[1]Department of Animal Health and Production, Yobe College of Agriculture, Gujba, P. M. B. 1104, Damaturu, Nigeria; and [2]Animal Production Programme, Abubakar Tafawa Balewa University, P. M. B. 0248, Bauchi, Nigeria; and [3]Federal College of Animal Health and Production, National Veterinary Research Institute, P. M. B. 01, Vom, Nigeria

ABSTRACT

In an 8 week – experiment the effect of differently processed sesame seed (SS) as a source of dietary methionine on the carcass characteristics of broiler chickens was investigated. Five iso-nitrogenous diets containing 0.00% sesame seed (NOSS) in diet 1 (Control) and 15.00% each of raw sesame seed (RASS), Roasted sesame seed (ROSS), boiled and dried sesame seed (BDSS) and soaked and dried sesame seed (SDSS) in diets 2, 3, 4 and 5 respectively, were formulated. The highest phytic acid (PA) reduction (52.99%) was obtained with soaking. Similarly, percent amino acid was marginally increased with soaking. However, none of the processing methods adversely affected the amino acid (AA) composition of the seed. There were no significant (p>0.05) differences in carcass yield and the yield of thigh, drumstick and abdominal fat amongst treatments. The percent wing was significantly (p<0.05) higher in diet 2 than diet 4, but the differences between diets 2, 1, 3 and 5 and between diets 4, 3 and 5 were not significant (p>0.05). Significantly (p<0.05) higher breast meat yields were recorded in diets 1, 2 and 5 compared to diets 3 and 4 (heat treated) which did not differ significantly (p<0.05) from each other. Processing had no effects on percent liver, heart and gizzard. The maximum PA reduction make soaking a safer processing method especially when higher levels of inclusion of the seed are to be considered. Finally SS could replace synthetic methionine in broiler chicken diets without adverse effects on Carcass traits.

Key words: Sesame seed, methionine, broilers, carcass characteristics

INTRODUCTION

The high cost of animal protein in Nigeria has necessitated the use of more plant protein sources in poultry feeding (Faniyi, 2002). Soyabean which is a proven source of protein in monogastic rations (Tion and Adeka, 2000) has been used to reduce the requirement for fish meal (Fanimo and Tewe, 1994). Apart from animal protein foods, soyabean is the source of the protein most suitable for poultry (Smith, 2001). In the un-extracted state, it is high in fat (18%), low in fibre (5%) and contains up to 38% crude protein (Smith, 2001). However, like most oilseeds soyabean protein is deficient in methionine and its use in livestock feeding requires supplementation with synthetic methionine to levels up to 5% (Serres, 1999). The effect of methionine on carcass characteristics of broilers has been reported. Huyghebaert and Pack (1996) and Yalcin *et al.* (1999) observed that slaughter and breast meat yields increased with the supplementation of the diet with methionine. In Nigeria the cost of synthetic methionine continues to increase and there is need to explore alternative sources.

Sesame (*Sesamum indicum* L) is a drought – tolerant crop adapted to many soil types (Ram *et al.*, 1990). In Nigeria, sesame is grown in the northeast, southeast and southwest zones (Presidential Task Force, 1992). According to Ahmed (2005) there are about 335,000 hectares under sesame cultivation in Nigeria with yields of between 1.5 – 2.0 tonnes/hectare. The seed contains 22-25% crude protein while the meal, after oil extraction contains about 46% (Peace Corps, 1990). The amino acid (AA) composition of the SS protein is similar to that of soyabean with the exception of low lysine (Mamputu and Buhr, 1991) and higher methionine in SS (Olomu, 1995). The seed is high (up to 6.7%) in crude fibre (Beckstrom -Sternberg *et al.*, 1994) and contains up to 5% phytic acid (PA), an anti-nutrient (Mulky *et al.*, 1989, Mukhopadhyay and Ray, 1999). There are reports on the use of sesame seed and meal as source of protein in poultry diets, but there is little or no documented information on its use as source of dietary methionine to poultry.

This study reports the effect of differently processed SS as a source of dietary methionine on some carcass traits

*Author for correspondence

of broiler chickens.

MATERIALS AND METHODS

Source and processing of sesame seed (SS)

The seed of the white variety of sesame was used for the experiment. The seed was purchased from Pulka market in Borno State, screened and winnowed to remove sand, chaff and foreign particles. The cleaned seed was then processed using the following four (4) methods;

I. Raw sesame seed (RASS): The dried raw seed obtained after screening and winnowing was bagged and labelled RASS

II. Roasted Sesame Seed (ROSS): The seed was roasted in a heated aluminium pot for 30 minutes, left to cool and then bagged and labelled ROSS;

III. Boiled and Dried Sesame Seed (BDSS): The seed was boiled in water at 100ºC for 30 minutes, sun-dried for 72 hours, bagged and labelled BDSS, and

IV. Soaked and Dried Sesame Seed (SDSS): The seed was soaked in water for 24 hours, sun-dried for 72 hours, bagged and labelled SDSS.

Experimental birds and management

Two hundred (200) 7-day old Anak 2000 broiler chicks raised together on floor for the first 6 days were used for the experiment which lasted 8 weeks (5th March - 4th May, 2005). On the 7th day, the chicks were individually weighed and assigned to 5 groups (treatments) of 40 chicks each in a completely randomized design. Each group was further divided into four (4) replicates of 10 birds per replicate. Each replicate of 10 birds was housed in a floor pen (1.95 m^2) with the floor covered with wood shavings as litter material. The birds were vaccinated at weeks 2 and 4 against Gumboro disease and at week 3 against Newcastle disease.

Experimental diets

Five (5) iso-nitrogenous starter and finisher diets were formulated for the study. Diet 1 which was the control contained 0.00% (NOSS) while diets 2,3,4 and 5 contained 15.0% each of RASS, ROSS, BDSS and SDSS respectively (Table 1). The control diet contained synthetic methionine which was replaced in the other diets with the introduction of SS. The diets and clean drinking water were provided *ad-libitum* throughout the experimental period of 8 weeks. Broiler starter mash was fed for 3 weeks (i.e., 4 weeks of age) and the finisher mash fed from week 5 to the end of the experiment.

Table 1. Broiler diets containing differently processed sesame seed

	Starter diets					Finisher diets				
Ingredients (%)	1	2	3	4	5	1	2	3	4	5
Maize	41.95	33.79	33.79	33.79	33.79	50.78	42.40	42.40	42.40	42.40
Wheat bran	10.50	10.20	10.20	10.20	10.20	12.00	12.05	12.05	12.05	12.05
Soyabean (full fat)	39.40	32.46	32.46	32.46	32.46	29.00	22.00	22.00	22.00	22.00
Sesame seed	-	15.00	15.00	15.00	15.00	-	15.00	15.00	15.00	15.00
Fish meal	5.00	5.00	5.00	5.00	5.00	5.00	5.00	5.00	5.00	5.00
Bone meal	2.40	2.90	2.90	2.90	2.90	2.40	2.90	2.90	2.90	2.90
Methionine	0.10	-	-	-	-	0.10	-	-	-	-
Lysine	0.10	0.10	0.10	0.10	0.10	0.10	0.10	0.10	0.10	0.10
Premix*	0.25	0.25	0.25	0.25	0.25	0.25	0.25	0.25	0.25	0.25
Salt	0.30	0.30	0.30	0.30	0.30	0.30	0.30	0.30	0.30	0.30
Total	100.00	100.00	100.00	100.00	100.00	100.00	100.00	100.00	100.00	100.00

*Premix from Bio-organics supplied/kg: Vit A = 4,000, 000.00 IU; Vit D_3 = 800,000.00 IU; Vit. E = 9,200.00 mg; Niacin = 11,000.00 mg; Vit B_1 = 720.00 mg: Vit B_2 = 2000.00 mg; Vit B_6 = 1,200.00 mg; Vit B_{12} = 600.00 mg; Vit K_3 = 800.00 mg; Panthotenic acid = 3000.00 mg; Biotin = 240.00 mg; Folic acid = 300.00 mg; Choline chloride = 120,000.00 mg; Cobalt = 80.00 mg; Copper = 1,200.00 mg; Iodine = 400.00 mg; Iron = 800.00 mg' Manganese = 16,000.00 mg; Selenium = 80.00 mg; Zinc = 12,000.00 mg.

Data collection

At the end of the experiment (9th week of age) 8 birds were randomly selected per treatment (i..e., 2 bird per replicate) fasted overnight (12 h) and used for carcass studies. Early in the morning (6.00 am) the birds were individually weighed, slaughtered and scalded in hot water (50ºC) for about one (1) minutes. Scalded birds were plucked, eviscerated and dressed. The dressed chicken was weighed and the weight expressed as a percentage of the live weight. Some cut up parts (wings, thighs, drumsticks and breast muscle) and the abdominal fat were also weighed and expressed as a percentage of the live weight.

Chemical analysis

A sample of the seed from each of the processing methods was analysed for amino acid (AA) profile using methods described by Spackman *et al.* (1958) and phytic acid (PA) content using the method of McCance and Widdowson (1935) as modified by Steward (1974). Diets formulated from the differently processed seeds and the raw seed were also analysed for proximate composition (AOAC, 1990).

Statistical analysis

Analysis of variance (Steel and Torrie, 1980) was carried out on data using the SPSS package (SPSS, 2001).

RESULTS

The amino acid composition of the differently processed sesame seed and the chemical composition of the experimental diets and sesame seed are shown in Tables 2 and 3, respectively. With the exception of isoleucine and tyrosine the level of all the amino acids analysed improved slightly with soaking. However, none of the processing methods adversely affected the amino acid composition of the seed. The raw sesame seed (RASS) contained higher phytic acid than the processed seeds. The highest phytic acid reduction (52.99%) was obtained with soaking followed by boiling (40.00%) and roasting (27.06%).

Table 2. Effect of processing on amino acid composition and phytic acid content of sesame seed

	Processing methods			
Amino acid (%)	RASS	ROSS	BDSS	SDSS
Lysine	1.36	1.36	1.34	1.40
Histidine	1.25	1.24	1.26	1.28
Arginine	5.20	5.54	5.56	6.02
Aspartic Acid	5.55	5.50	5.52	5.57
Threonine	1.95	1.90	1.92	1.99
Serine	3.11	3.10	3.09	3.21
Glutamic Acid	9.00	8.58	8.50	9.06
Proline	3.60	3.61	3.57	3.64
Glycine	5.05	5.00	4.98	5.19
Alanine	2.70	2.65	2.67	2.72
Cystine	1.02	0.75	0.80	1.03
Valine	2.85	2.86	2.80	2.88
Methionine	1.60	1.58	1.59	1.63
Isoleucine	2.28	2.23	2.24	2.26
Leucine	3.60	3.60	3.58	3.62
Tyrosine	2.20	2.16	2.19	2.18
Phynelalanine	2.48	2.46	2.49	2.50
Phytic Acid (µg/g)	42.50	31.00	25.50	19.98
Phytic Acid Reduction (%)	-	27.06	40.00	52.99

RASS: raw sesame seed; ROSS: roasted sesame seed; BDSS: boiled and dried sesame seed; SDSS: soaked and dried sesame seed

From the proximate composition of the diets, the values of ether extract, crude fibre and ash appeared to be increased in sesame-based diets compared to the control. Similarly, the methionine levels were better in the sesame

Table 3. Proximate composition of the experimental diets and sesame seed

Nutrients (%)	Starter diets					Finisher diets					Sesame seed
	1	2	3	4	5	1	2	3	4	5	
Dry matter (DM)	95.73	96.31	96.22	96.16	95.91	95.72	95.97	96.16	95.55	95.80	93.23
Crude protein (CP)	23.37	23.42	23.51	23.36	23.61	21.39	21.03	21.34	21.27	21.48	26.14
Ether extract (EE)	6.95	10.33	10.73	11.38	10.87	11.40	12.15	12.77	12.04	12.16	57.58
Crude fibre (CF)	7.71	8.96	7.51	9.40	6.99	7.75	8.80	8.59	9.56	8.42	7.03
Total ash	12.98	17.16	14.53	17.13	15.98	7.80	9.69	9.15	10.60	10.77	6.63
Nitrogen free extract (NFE)	48.99	40.13	43.72	39.73	42.98	51.66	48.69	48.15	46.53	49.17	6.62
Lysine[1]	1.44	1.48	1.48	1.47	1.48	1.26	1.26	1.26	1.26	1.26	1.27
Methionine[1]	0.48	0.57	0.57	0.57	0.57	0.46	0.54	0.54	0.54	0.54	0.54
ME (Kcal/kg)	2888.01	2894.38	2982.21	2907.48	2903.69	3186.72	3190.87	3193.39	3180.38	3041.86	4962.21

Metabolizable energy (ME) calculated according to the formula of Ichaponani (1980), i.e., ME (Kcal/kg) = 432 + 27.91 (CP + NFE + 2.25 × EE); [1]Calculated using table values for other ingredients and analysed values for sesame seed from different processing methods

-based diets.

The results of carcass studies are presented in Table 4. There were no significant (p>0.05) treatment differences in the slaughter and carcass weights. Similarly, carcass yield and the yields of thighs, drumsticks and abdominal fat did not differ (p>0.05) amongst treatments. The percent wing was significantly (p<0.05) higher in diet 2 compared to diet 4, but did not differ (p>0.05) between diets 2, 3 and 5. Significantly (p<0.05) higher breast muscle yields were recorded in diets 1, 2 and 5 compared to diets 3 and 4 (containing the heat processed seeds) which did not differ significantly (p>0.05) from one another. Percent liver, heart and gizzard did not differ (p>0.05) amongst treatments.

TABLE 4. Carcass characteristics of broiler chickens fed diets containing differently processed sesame seed as a source of methionine

Parameter	Diets					
	1	2	3	4	5	SEM
Slaughter Weight	2075.00	2077.50	2148.50	2162.17	2062.50	20.73^{NS}
Dressed weight	1390.87	1401.69	1386.00	1370.17	1376.93	5.46^{NS}
As % live weight						
Carcass	67.03	67.47	64.51	63.37	66.76	0.61^{NS}
Wings	7.30^{ab}	7.99^{a}	6.85^{ab}	6.18^{b}	7.60^{ab}	0.18*
Thighs	11.50	11.64	11.10	11.15	11.22	0.13^{NS}
Drumsticks	9.82	9.82	9.27	9.85	10.34	0.17^{NS}
Breast muscle	16.52^{a}	16.35^{a}	13.79^{b}	13.30^{b}	16.23^{a}	0.31*
Abdominal fat	1.13^{c}	2.34^{a}	1.78^{b}	1.98^{ab}	1.62^{bc}	0.16*
Liver	1.48	1.51	1.50	1.49	1.48	0.01^{NS}
Heart	0.31	0.35	0.28	0.29	0.26	0.02^{NS}
Gizzard	2.29	2.30	2.28	2.26	2.27	0.01^{NS}

a, b = Means within the row bearing different superscripts differ; significantly (p<0.05); SEM = standard error of the mean; NS = not significant; * = significant

DISCUSSION

The values obtained for all the amino acids analysed were superior to those reported elsewhere for sesame seed (SS) (Mulky *et al.*, 1989; Olomu, 1995). The phytic acid (PA) content of the experimental seed (42.50 µg/g) was lower than the 50 µg/g reported by Mulky *et al.* (1989). Soaking in water reduced PA more than any other processing method. Nestares *et al.* (1999) reported a significant reduction of PA in soaked chickpea. Phytic acid was also reduced by boiling more than roasting. This suggests that PA is lost more through hydrolysis than the action of heat. The crude protein of SS used in this experiment was higher than the 22-25% reported in literature (Peace Corps, 1990; Mamputu and Buhr, 1991; Aduku, 1992; Olomu, 1995). The difference may be attributed to the variety. Wide varietal differences in the nutritional quality of SS have been reported (Oplinger *et al.*, 1997). Another possible explanation could be the extent of cleaning. Sesame seed is usually associated with too much sand and other particles and if not thoroughly cleaned the level of other nutrients (on dry matter basis) will be reduced and that of fibre increased. The oil content of the seed in this experiment falls within the range (50-60%) reported by Brar and Ahuja (1979) and Sirato-Yasumoto *et al.*, (2001). The crude fibre of the seed (7.03%) is within the range of 6.7% (Beckstrom-Sternberg *et al.*, 1994) and 10.3% (Olomu, 1995). The increased in ether extract, crude fibre and ash in SS-based diets compared to the control may be due to the high concentration of these nutrients in SS than in soyabean as reported by Olomu (1995). The metabolizable energy (calculated) of SS (4962.21 kcal/kg) compares well with the 5190 kcal/kg obtained by Olomu (1995). Both the crude protein and the energy of all the diets met the requirements of broiler chickens (Aduku, 1992; NRC, 1994; Olomu, 1995; Smith, 2001). The crude fibre in all the diets was higher than the maximum of 5.0% recommended by smith (2001) for broilers.

The mean slaughter weights were lower than those reported by the NRC (1994) for broiler chickens aged 9 weeks. During the last month of the experiment the mean temperature was 42°C. This might have affected weight gain as observed by Smith (2001). The carcass yield in all the diets compared favourably with values (65-77%) reported in literature (Oluyemi and Robert, 1988, Deschepper and Degroote, 1995, Nwokoro and Tewe, 1998) for

9-week-old broilers. The yield of the wings, thighs and drumsticks were slightly lower than the values (8.21, 12.92 and 11.67%, respectively) reported by Oluyemi and Roberts (1988). The reason for the significantly lower breast muscle yields on the diets containing heat-treated SS (ROSS and BDSS) was not clear, but probable due to some denaturing of protein by the heat. With the exception of these two (2) groups, breast muscle recorded on the other 3 groups were within the range of 14-17% observed by Mack *et al.* (1999). They were however; lower than the 17.4% reported by Oluyemi and Roberts (1988). The high ambient temperature (42^{o}C) might have affected breast meat deposition. Smith (2001) observed a linear reduction in the amount of breast meat in broilers as the ambient temperature increases.

From the results, it can be concluded that sesame seed methionine can replace synthetic methionine in broiler chickens diets without adverse effect on carcass traits. However, soaking the seed is desirable as it proves to be most efficient in reducing the PA content of the seed. This may prove useful when higher levels of inclusion are considered.

REFERENCES

Aduku, A. O. (1992). Practical livestock feeds production in tropics. First edition, S. Asekome and Co. Publishers. P.O. Box 15, Samaru, Zaria.

Ahmed, M. F (2005). Sesame production technology and strategies to increase production in Nigeria. A paper presented at the National Sesame Seed Forum Stakeholders Meeting, Le Meridien, Abuja, Nigeria, 29-30 August 2005.

AOAC (1990). *Official Methods of Analysis* 19th edition. Association of Official Analytical Chemist, Washington DC.

Beckstrom-Sternberg, S. M., Duke, J. A. and Wain, K. K. (1994). The ethnobotany database." http//ars-genome. Cornell.ed/egi-bin/Webace/webace?db=ethnobotbd (Data version July, 1994).

Brar, G. S. and Ahuja, K. L. (1979). Sesame: its culture, genetics, breeding and biochemistry In: Malik, C.P. (ed). *Annual Review of Plant Science.* Kalyani Publishers, New Delhi. pp. 245-313.

Deschepper, K. and Degroote, G. (1995). Effect of dietary protein, essential and non-essential amino acids on the performance and carcass composition of male broiler chickens. *Br. Poultry Sci.* 36, 229-245.

Fanimo, A. O. and Tewe, O. O. (1994). Comparative nutritional evaluation of full-fat soyabean and some animal protein concentrates. *Trop. Oilseed J.* 2(1), 95-104.

Faniyi, G. F. (2002). Inclusion of discarded cashew kernels in the diets of cockerel chicks. In: Fanimo, A. O and Olanite, J. A. (eds). *Contributory Role of Animal Production in National Development. Proceedings 7th Annual Conference of Animal Science Association of Nigeria*, September 16-19, 2002 University of Agriculture, Abeokuta, Nigeria. pp. 109-111.

Huyghebaert, G. and Pack, M. (1996). Effects of dietary protein content, addition of non-essential amino acids and dietary methionine to cystine balance on responses to dietary sulphur-containing amino acids in broilers. *Br. Poultry Sci.* 37, 623-639.

Ichaponani, J. (1980). Developing, availability and reliable test to predict biological availability of nutrients in poultry feeds. *Report of the Indian Council for Agricultural Research*, India.

Mack, S., Bercovici, D., De Groote, G., Leclercq, B., Lippens, M., Pack, M., Schuttle, J. B. and Van Cauwen-berghe, S. (1999). Ideal amino acid profile and dietary lysine specification for broiler chickens of 20 to 40 days of age. *Br. Poultry Sci.* 40, 257-265.

Mamputu, M. and Buhr, R. J. (1991). Effects of substituting sesame meal for soyabean meal on layer performance. *Poultry Sci.* 70 (Supplement 1), 77.

McCance, R. A and Widdowson, E. H. (1935). Estimation of phytic acid. *J. Biochem.* 29, 2694-2695.

Mukhopahyay, N. and Ray, A. K. (1999). Effects of fermentation on the nutritive value of sesame seed meal in the diets for rohu, Labeorchita (Hamilton), fingerlings (Abstract) http://www.ingenta.connect.com/content/bsc/anut/1999/00000005/00000004/art00101

Mulky, M. J., Cherian, K. M. and Ghandhi, V. M. (1989). Nutritional quality and safety of animal feedstuffs. In: P. N. Bhat, K. K. Menon and H. C. Srivastava (eds), *Animal Productivity.* Oxford and IBH Publishing Co. PVT, Ltd, New Delhi, India.

Nestares, T., Barrionuevo, M., Urbano, G and Lopez-Frias, M. (1999). Effect of processing methods on the calcium, phosphorus and phytic acid contents and nutritive utilization of chickpea (*Cicer arietinum* L.). *J. Agric. Food Chem.* 47(7), 2807-2812.

NRC. (National Research Council, 1994). *Nutrient Requirement of Poultry*, 9th Revised Edition. National Academy Press, Washington, DC

Nwokoro, S. O. and Tewe, O. O. (1998). Effect of different levels of dietary methionine on the carcass characteristics of finishing cockerels. *Nig. J. Anim. Prod.* 25(1), 25-30.

Olomu, J. M. (1995). *Monogastric Animal Nutrition.* A. Jachem Publications, Benin City , Nigeria pp. 153-154.

Oluyemi, J. A. and Roberts, F. A. (1988). *Poultry Production in Warm Wet Climates.* Low Cost Editions. McMillan Education Limited, London and Bashingstoke.

Oplinger, E.S ., Putnam, D. H., Kaminski, A. R., Hanson, C. V., Oelke, E. A. Shutte, E. E. and Doll, J. D (1997). Sesame. University of Wisconsin-Madison, W153706 last update August 27, 1997 by aw.

Peace Corps (1990). New Crop Production Handbook, Information Collection and Exchange; Yermanos, D.M (ed). Washington, DC 20526, USA.

Presidential Task Force on Alternative Formulations of Livestock Feed (1992). Report of livestock numbers, feed resources, inventory and supplies, vol.2. Office of the Secretary to the Government of the Federal Republic of Nigeria, Abuja, FCT. 93pp.

Ram, R., Catlin, D., Romero, J. and Cowley, C. (1990). Sesame: New approaches for crop improvement. In: J. Janick and J.E. Simon (eds). *Advances in New Crops.* Timber Press, Portland, OR. pp.225-228.

Serres, H. (1999). *Manual of Pig Production in the Tropics*. CABI Publishing pp. 108.

Sirato-Yasumoto, S., Katsuta, M., Okuyamo, V., Takahashi, Y. and Ide, I. (2001). Effect of sesame seeds rich in sesamin and sesamolin on fatty acid oxidation in rat liver. *J. Agric. Food Chem.* 49, 2647-2651.

Smith, A. J. (2001). *Poultry;* The Tropical Agriculturalist, Revised Edition, Macmillan Education Ltd., London and Oxford.

Spackman, D.H., Stein, W.H. and Moore, S. (1958). Automatic recording apparatus for use in the chromatography of amino acids. *Anal. Chem.* 30, 1990-1991.

SPSS (2001). *Statistical Package for Social Science*. PC Version, SPSS Inc. 444 N Michingan Avenue Chicago, United States of America.

Steel, R. G. D. and Torrie, J. H. (1980). *Principles and Procedures of Statistics, a Biometrical Approach*, 2nd edition McGraw Hills Book Co., New York, USA

Stewart, E. (1974). *Chemical Analysis of Ecological Materials.* Blackwell Scientific, Oxford (UK). pp. 298-312.

Tion, M. A and Adeka, I. A (2000). The effect of raw or heat processed full-fat soyabean on broiler performance, In: Ukachukwu, S. N., Ibeauchi, J. A., Ibe, S. N.; Ezekwe, A. G. and Abasiekong, S. F. (eds). *Animal Production in the New Millennium: Challenges and Options. Proceedings, 25th Annual Conference Nigerian Society of Animal Production (NSAP)*, Michael Okpara University of Agriculture, Umudike, Nigeria, 19-23 March, 2000 pp. 197-200.

Yalcin, S., Ozkan, S., Acikgoz, Z. and Ozkan, K. (1999). Effect of dietary methionine on performance, carcass characteristics and breast meat composition of heterozygous naked neck (Na/na$^+$) birds under spring and summer conditions. *Br. Poultry Sci.* 40, 688-694.