EFFECT OF SUPPLEMENTAL ANTIOXIDANT ON THE QUALITY OF BROILER RATIONS CONTAINING HIGH LEVELS OF FAT AND STORED AT HIGH TEMPERATURE

Abdul Waheed, Tanveer Ahmad[1] and Zia-ul-Hasan
Dept. of Animal Nutrition, University of Agriculture, Faisalabad and
[1]Dept. of Animal Sciences, University of Arid Agriculture, Rawalpindi, Pakistan.

ABSTRACT

Broiler rations containing 2, 3 or 4 per cent corn oil were supplemented with a normal (125mg/kg) or higher (175mg/kg) level of Santoquin, an antioxidant. These rations were stored at 40°C for 42 days. The extent of fat oxidation in terms of acid value of stored feed was determined at weekly intervals from day one till the end of storage period. High storage temperature (40°C) resulted in significant oxidation of fat. The highest acid value (13.99 ± 0.05) was observed in rations containing 4 per cent oil, whereas the lowest (9.82 ± 0.05) was in rations containing 2 per cent oil. Oxidation of oil in rations increased significantly ($P<0.05$) with increasing storage period. Supplementation of higher levels of Santoquin (175mg/kg) significantly improved ($P<0.05$) the stability of oil.

Key Words: Rancidity, high fat, temperature, storage time, antioxidant

INTRODUCTION

During hot summer months feed intake of the birds is substantially reduced probably due to more heat production in the body. So adjustments need to be made in feed formulation by using more dietary fat as energy source vice carbohydrates. The diet with high fat contents may result in extra caloric effect (Hurwitz *et al.*, 1980), therefore it is required to minimise the apparent energy requirement. Devegowda and Ramappa (1986) found that by increasing the fat content in broiler rations, an increase in weight gain could be achieved with less amount of feed.

During recent years, it has become a common practice to add more fat or oil to commercial broiler rations to increase energy density. Vegetable oils rich in polyunsaturated fatty acids (PUFA) have an additional advantage as compared to saturated fats due to the fact that they are more digestible. But polyunsaturated fatty acids are highly sensitive towards oxidation during storage. They are likely to turn rancid at high environmental temperature during storage.

Rancidity can be detected by the addition of antioxidants in feeds, as they retard the oxidative spoilage (Warraich, 1972). The relative protective effect of 0.02% antioxidant against oxidative rancidity depends on storage time (Chahine, 1978) and storage temperature (Villwock and Hartfiel, 1982). The beneficial effects of ethoxyquin (EQ) and butylated hydroxy tolune (BHT) as antioxidants have been well documented (Franic, 1985). Santoquin (Ethoxyquin 1,2-dihydro-6-ethoxy-2,2,4-trimethylquinoline, EQ), a synthetic antioxidant approved for use in poultry feeds at 125 ppm, is a widely used feed grade antioxidant that can prevent the oxidation of lipids and lipid soluble components in the feed (Cabel and Waldroup, 1989).

The study under report was conducted to determine the optimum levels of antioxidant (Santoquin) in broiler diets containing high levels of added oil and stored for quite sometime under conditions similar to those found in the field during hot environment.

MATERIALS AND METHODS

Three basal iso-caloric and iso-nitrogenous broiler rations containing 2, 3 or 4 per cent corn oil were formulated. Each of these rations was supplemented with a normal (125 mg/kg) or a higher (175 mg/kg) level of Santoquin (Table 1). About a kilogram of each of the mixed rations was packed separately in 126 small bags of the same polythene material which is traditionally used for poultry feed packing. These bags were then stored in a chamber fitted with a thermostatically controlled heater. The temperature of the chamber was fixed at 40°C. At the start of experiment and thereafter, at weekly intervals, triplicate bags of each ration were drawn and analysed in duplicate for acid value (AOAC, 1990).

The data thus obtained were analysed by using analysis of variance technique in completely

Table 1: Composition of eexperimental rations (%)

Ingredients	Rations					
	AS1	AS2	BS1	BS2	CS1	CS2
Corn	31	31	28	28	25.5	25.5
Rice broken	20	20	20	20	20	20
Rice polish	3	3	3	3	3	3
Wheat bran	0.5	0.5	2	2	3	3
Cottonseed meal	6	6	6	6	6	6
Rapeseed meal	2	2	3.5	3.5	5	5
Corn gluten 60%	6	6	4	4	2	2
Soybean meal	17	17	17	17	17	17
Fish meal	8	8	8	8	8	8
Blood meal	1	1	2	2	3	3
Corn oil	2	2	3	3	4	4
Antioxidant (Santoquin)	0.0125	0.0175	0.0125	0.0175	0.0125	0.0175
Di-calcium phosphate	0.75	0.75	0.75	0.75	0.75	0.75
Limestone	1.25	1.25	1.25	1.25	1.25	1.25
Molasses	1	1	1	1	1	1
Vitamin and mineral premix	0.5	0.5	0.5	0.5	0.5	0.5
Nutrients	(%)					
Crude protein	23.01	23.01	23.02	23.02	22.99	22.99
Metabolizable energy (Kcal/kg)	3003	3003	2998	2998	3003	3003
Crude fiber	3.8	3.8	4.0	4.0	4.25	4.25
Calcium	1.04	1.04	1.06	1.06	1.08	1.08
Phosphorus	0.48	0.48	0.48	0.48	0.48	0.48
Lysine	1.10	1.10	1.17	1.17	1.23	1.23
Methionine	0.65	0.65	0.61	0.61	0.57	0.57

randomised design with 7x3x2 factorial arrangement. Means of significant results were compared by Duncan's multiple range test (Steel and Torrie, 1984).

RESULTS AND DISCUSSION

The average acid values of the rations containing different levels of fat (2, 3 or 4%) were found to be minimum (10.37 ±. 0.08) at the start of the experiment (Table 2). However, it started increasing at a variable rate, with the passage of storage time. This increase in acid value was more pronounced in case of feed containing the highest level of fat. It was low ($P<0.05$) during first 14 days of storage, but thereafter, the values started increasing significantly ($P<0.05$) at each successive storage period.

There was an inherent significant ($P<0.05$) difference in acid values of the rations containing different levels of fat, probably due to the presence of oxidation which might have already been there in the oil which was mixed in the feed. The trends of increase in acid value in different rations, during storage, for various time intervals was corresponding to their fat content. A ration containing 2 per cent oil and stored for 42 days had similar acid value as that of a ration containing 3 per cent fat and stored for 21 days or that of a ration with 4 per cent fat and stored for 14 days.

Rancidity of the oil in broiler rations, as measured in terms of acid value of the rations containing different levels of fat and supplemented with synthetic antioxidant (Santoquin), was significantly ($P<0.01$) affected by storage time and level of antioxidant. The increase in acid value was observed at a variable rate with the increasing storage time. However, increase was less ($P<0.05$) during first 14 days of feed storage (Tables 2 and 3) but more pronounced during further storage. These results are in close agreement with the results of Trebusiewicz *et al.* (1980), who found an increase in acid value in stored feed, containing 4 per cent beef tallow, from 8.66 to 14.33 in darkness and 21.99 in light in starting feeds and from 9.49 to 19.39 and 26.38 in finishing feeds. Very high acid values recorded in their study might be due to long storage of feed and or feed stored without antioxidants. Significant ($P<0.01$) effect of fat and storage period on acid value have also been reported by Ramzan (1993), who found that acid value increased significantly with increasing fat per cent and storage time. Acid value increased at 2 per cent fat level from 8.33 to 11.12 in starter and from 9.26 to 12.60 in finisher rations. While at 4 per cent fat, acid value increased from 8.54 to 12.11 in starter and from 9.25 to 12.86 in finisher ration. Similarly, acid

value also increased (P<0.01) with increase in storage time from 9.24 to 14.07 within 42 days storage period.

Welch (1977) reported that rancidity in oats increased at higher moisture content and with longer storage period. Free fatty acid content significantly increased in moist samples of oats stored for longer period. High level of dietary fat, polyunsaturation (Hilton, 1989; Squires *et al*., 1991), high temperature and humidity (Ponomareva, 1983) and long storage (Gulbrandsen *et al*., 1983) increased the potential for diet rancidity.

The results of analysis in respect of the effect of Santoquin level and storage period on acid value are shown in Table 3. Acid value of the feed containing different levels of synthetic antioxidant (Santoquin 125 and 175 g/ton) was similar and minimum at the start of the experiment. However, it increased (P< 0.01) with the passage of time. The level of Santoquin had a significant effect (P<0.05) on the acid value, the lower the level of antioxidant the higher was the oxidation of fat. The increase in acid value of the feeds containing two levels of Santoquin, was not significant till 7th day of storage. Thereafter, it increased significantly (P<0.05), yet the values did not differ between the two levels till 21st day of storage. Thereafter, the acid value of the rations supplemented with higher levels of

Table. 2 Average acid values as affected by fat percentage and storage period

Days of storage	Fat percentage			Mean
	2%	3%	4%	
0	9.82 ± 0.05^{m}	10.40 ± 0.04^{k}	10.85 ± 0.04^{ij}	10.37 ± 0.08^{f}
7	9.92 ± 0.05^{lm}	10.42 ± 0.04^{k}	10.95 ± 0.04^{hi}	10.43 ± 0.01^{f}
14	10.08 ± 0.07^{j}	10.87 ± 0.05^{kj}	11.13 ± 0.09^{gh}	10.70 ± 0.09^{e}
21	10.35 ± 0.05^{k}	11.11 ± 0.10^{gh}	11.94 ± 0.04^{e}	11.14 ± 0.12^{d}
28	10.72 ± 0.11^{j}	11.58 ± 0.08^{f}	12.69 ± 0.09^{c}	11.66 ± 0.15^{c}
35	10.96 ± 0.08^{hi}	11.95 ± 0.070^{e}	13.19 ± 0.22^{b}	12.04 ± 0.17^{b}
42	11.20 ± 0.06^{g}	12.39 ± 0.06^{d}	13.99 ± 0.05^{a}	12.53 ± 0.19^{a}
Mean*	10.44 ± 0.06^{c}	11.28 ± 0.08^{b}	12.11 ± 0.13^{a}	11.26 ± 0.07

[a-m]Means within columns with no common superscript differ significantly (P<0.05).
*[a-c]Means within row with no common superscript differ significantly (P<0.05).

Table. 3 Average acid values as affected by Santoquin level and storage period

Days of storage	Santoquin level (g/ton)		Mean
	125	175	
0	10.36 ± 0.11^{h}	10.36 ± 0.11^{h}	10.36 ± 0.08^{f}
7	10.48 ± 0.11^{h}	10.40 ± 0.10^{h}	10.43 ± 0.01^{f}
14	10.74 ± 0.12^{g}	10.65 ± 0.12^{g}	10.70 ± 0.09^{e}
21	11.17 ± 0.16^{f}	11.11 ± 0.20^{f}	11.14 ± 0.12^{d}
28	11.88 ± 0.21^{d}	11.45 ± 0.20^{e}	11.66 ± 0.15^{c}
35	12.10 ± 0.24^{c}	11.98 ± 0.25^{cd}	12.04 ± 0.17^{b}
42	12.63 ± 0.28^{a}	12.43 ± 0.10^{b}	12.53 ± 0.19^{a}
Mean	11.33 ± 0.10^{a}	11.19 ± 0.10^{b}	11.26 ± 0.07

[a-h]Means within columns with no common superscript differ significantly (P<0.05).
*[a-b]Means within row with no common superscript differ significantly (P<0.05).

Santoquin was significantly ($P<0.05$) lower than that supplemented with the lower level.

The addition of antioxidant (Santoquin) had a significant effect on acid value. Acid value of ration containing higher level of Santoquin was significantly lower than that supplemented with the lower level. The effect of Santoquin with storage period also significantly affected the acid values of the feeds. but the interaction of Santoquin and storage period was non significant. Bespolve and Kiselev (1993) reported that 0.02 and 0.04 per cent antioxidants had a preventing action on polyunsaturated fatty acids of feed during prolonged storage. However. mean acid values of stored feeds increased with each increasing level of storage period and fat percentage. These results differ slightly with the results of Ramzan (1993). who found acid values of 9.24. 9.26. 9.24 and 9.28 in feeds containing 0. 75. 125 and 175g endox per ton of feed. at the start of the experiment and 14.07. 12.36. 12.12 and 12.32 at 40th day of storage. The starter rations containing respective levels of endox had the acid values of 8.68. 8.40. 8.12 and 8.54. while the finisher rations had 13.44. 11.48. 10.92 and 10.64. respectively. The difference in acid values at 125g/ton and 175g ton endox was not significant but at these two levels the acid values were significantly lower than other lower levels and the control. These differences in acid values might be due to less efficiency of Santoquin at high temperature compared to endox. Yazych'Yan *et al.* (1985) concluded that during prolonged storage of a feed mixture with cholamine phosphate. there was less increase in acidity. Similarly. Chahine (1978) demonstrated that the relative protective effect of 0.02 per cent antioxidant against oxidative rancidity depended on storage time. It has been reported that Santoquin 150g ton prevents acidity during long term storage (Shemet and Martinenko. 1983: Wang *et al.*. 1997: Anjum: 1999: Khan *et al.*. 2001). Chahine (1978) concluded that butylated hydroxyanisole was the most effective antioxidant in fish meal stored for 8 months and ethoxyquin was nearly as effective. Pelvin and Lokteva (1980) reported that Santoquin significantly delayed destruction of unsaturated fatty acids and formation of secondary oxidation products. Santoquin and propionic acid significantly reduced acidity in grass meal stored for 6-10 months (Kntekhtsyan *et al.*. 1985).

High acid values in the present results may be due to the effect of high storage temperature (Villwock and Hartfiel. 1982) and the use of corn oil which contained more degree of un-saturation (Squires. 1991). However. the addition of higher level of antioxidant had a protective effect and the acid value of the rations was significantly ($P<0.05$) lower compared with the lower level of antioxidant added to the rations containing similar levels of corn oil.

Based on the results of the present study. it can be concluded that acid value of the rations increased due to prolonged storage at high temperature and addition of high fat levels. Supplementing the rations with antioxidants significantly improved the stability of fat in rations stored at high temperature with high levels of fat in the ration.

REFERENCES

Anjum M.I.. 1999. Effect of different levels of oxidised vegetable oil supplemented with different levels of antioxidant (Ethoxyquin) on broiler performance. M.Sc.(Hons.) Thesis. Dept. Anim. Nutr.. Univ. Agric.. Faisalabad. Pakistan.

AOAC.. 1990. Official methods of analysis of the Association of Official Analytical Chemists. 14th ed. Association of Analytical Chemist Inc. Arlington. Virginia. USA.

Bespolve. A. M. and A. L. Kiselev. 1993. A new antioxidant. Krolikovodstvo I Zverovodstvo. 5: 9. (Nutr. Abst. Rev.. 63: 650. 1993).

Cabel. M. C. and P. W. Waldroup. 1989. Research note: Ethoxyquin and ethylenediamine-tetraacetic acid for the prevention of rancidity in rice bran stored at elevated temperature and humidity for various lengths of time. Poult. Sci.. 68: 438-442.

Chahine. M. H.. 1978. Antioxidants to stabilise fish meal. Feedstuffs. 50: 28-29 (Nutr. Abst. Rev.. 49: 526. 1979).

Devegowda. G. and B. S. Ramappa. 1986. The "extra caloric" value of fat and high energy diets for poultry. Poult. Advisor. 19: 21-23.

Franic. I.. 1985. Control of rancidity developing in fish meals. Obiettivi e Documenti Veterinari. 6: 43-48 (Nutr. Abst. Rev.. 56: 68. 1986).

Gulbrandsen. K. E.. A. Aksnes and L. R. Njaa. 1983. Oxidation fat and methionine during storage of protected and non-protected fish meal from mackerel. Fiskeridirectoratets Skrifter. Ernaring. 2: 109-16. (Nutr. Abst. Rev.. 54: 3058. 1984).

Hilton. J. W.. 1989. Antioxidants: function. types and necessity of inclusion in pet foods. Canadian Vet. J.. 30: 682-684.

Hurwitz. S.. M. Weiselberg. U. Eisner. I. Bartov. G. Riesenfeld. M. Sharvit. A. Niv and S. Bornstein. 1980. The energy requirements and performance of growing chickens and turkeys as affected by environmental temperature. Poult. Sci.. 59: 2290-2299.

Khan. S.H., B.M. Bhatti and R. Sardar. 2001. Acid values of vegetable oils and poultry feed as affected by storage period and antioxidant. Pakistan Vet. J., 21 (4): 194-197.

Kntekhtsyan. A.A., L. Y. Davidchik and V. A. Pleshko. 1985. Use of a mixture of Santoquin and propionic acid in stabilizing carotene in grass meal. Khimiya v Selskom Khozyaistive. 23: 30-32 (Nutr. Abst. Rev., 55: 5459. 1985).

Pelvin. A. D. and T. V. Lokteva. 1980. Effect of Santoquin on fatty acid and fractional composition of lipids. Khimiya a sel'skom Khozyaistve. 18: 40-41. (Nutr. Abst. Rev., 51: 3381. 1981).

Ponomareva. L. V., 1983. Effect of length and conditions of storage on the quality of feeds used in fish culture. Rybnoe Khozyaistvo. Mosco USSR. 5: 31-33. (Nutr. Abst. Rev., 55: 10. 1985).

Ramzan. M., 1993. Effect of different levels of endox and fat on the quality of stored feed and performance of broiler chicks. M.Sc Thesis. Univ. of Agri., Faisalabad. Pakistan.

Shemet. R. S. and G. N. Martinenko. 1983. Evaluation of feeds containing fat during storage. Veterinariya. Kiev. USSR. 58: 58-60. (Nutr. Abst. Rev., 54: 5040. 1984).

Squires. E. J., E. V. Valdes. J. Wu. and S. Leeson. 1991. Research note: Utility of the thiobarbituric acid test in the determination of quality of fats and oils in feeds. Poult. Sci., 70: 180-183.

Steel. R. G. D. and J. H. Torrie. 1984. Principles and Procedures of Statistics: A biometerical Approach. 2nd edition. McGraw-Hill Book Company. New York.

Trebusiewicz. B., B. Chelmonska., T. Gwara., D. Jamroz and A. Mazanowska. 1980. Use of the waste animal fat in feeds for broiler chickens. Stability of fats in feeds for broiler chickens. Przemyslu Praszowego. 19: 16 (Nutr. Abst. Rev., 52: 2617. 1982).

Villwock. U. and W. Hartfiel. 1982. Effect of different types and amounts of fat and antioxidants. and temperature and duration of storage on peroxide formation and content of antioxidant residues in mixed feeds. Zeitschrift fur Tierphysiologie. 48: 130-138 (Nutr. Abst. Rev., 53: 2316. 1983).

Wang. S.Y., B. Walter., M. Philip., D. Julia and S. William. 1997. Effect of Sanataquin and oxidised fat liver and intestinal glutathione in broilers. Poult. Sci., 76: 961-967

Warraich. M.A., 1972. Stability of sunflower oil as affected by antioxidants under varying conditions. M.Sc. Thesis., Univ. of Agri. Faisalabad. Pakistan.

Welch. R.W., 1977. The development of rancidity in husked and naked oats after storage under various conditions. J. Food Sci. Agric., 28: 269-274.

Yazych'Yan A. S., A. M. Karadzhyan., N. N. Natisshvili. and K. M. Aleksandryan. 1985. Changes in total lipids and acidity in feed mixtures during prolong storage. Trudy Erevanskogo Zooverterinarnogo Instituta. 58: 122-125 (Nutr. Abst. Rev., 58: 4774. 1988).