



Chapter 10. Antioxidants in Compounded Feeds

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1. INTRODUCTION

Just as oxidation can cause rust and deterioration in metals, a similar type of oxidation occurs in feeds and feedstuffs, resulting in rancidity of fats, destruction of vitamins A, D, and E, pigments (carotenoids) and amino acids with resultant lowered biological energy values for the diet. If this destruction is allowed to proceed unchecked in a feed, or even in a single ingredient, a lowered feed consumption may result in disastrous nutrient deficiencies. Researchers in a number of fields have been studying the various problems resulting from uncontrolled oxidation and have been developing ways of bringing these oxidation processes under control. It is noted that oxidative rancidity or lipid peroxidation, as contrasted with hydrolytic rancidity, results in a serious decrease in the energy value of a fat or oil.

Undesirable oxidation in feeds may be combatted in several ways. Care should be used to make certain that the ingredients included in the feeds provide adequate margins of safety of vitamins A, E, and other natural antioxidants; e.g., lecithin. The use of unstable fats and oils or other pro-oxidants in the feed should be minimized whenever possible.

2. CRITERIA FOR SELECTING FEED ANTIOXIDANTS

Antioxidants have been used in commercial fish foods in the USA for over 20 years. Although hundreds of chemicals have been tested, only a few have shown the qualifications necessary to make them suitable for use in preventing undesirable oxidations in feedstuffs, in finished feeds, and in the guts and carcasses of animals. In order for an antioxidant to be useful in animal feeding, it must have the following qualifications:

- (a) it must be effective in preserving animal and vegetable fats, vitamins, and other feed qualities subject to oxidative destruction;
- (b) it must be non-toxic to man and to farm animals (i.e., chickens, swine, fish, etc.);
- (c) it should be effective at very low concentrations; and
- (d) it must be low enough in cost to be economically practical.

3. COMMONLY USED FEED ANTIOXIDANTS

Of the chemical compounds that have been investigated thus far, three have been found to be outstandingly effective antioxidants for feeds and feed ingredients and can be used both efficiently and economically. They are:

- (a) Ethoxyquin (generic term: 1,2-dihydro-6-ethoxy-2,4- trimethylquinoline)
- (b) BHA (butylated hydroxyanisole);
- (c) BHT (butylated hydroxytoluene)

Ethoxyquin, however, has been demonstrated to be the most efficacious, followed closely by BHT and BHA.

With the advent of rations containing a high level of animal and vegetable fats, the requirement for antioxidant protection has become very apparent. The majority of studies over the last few years has focused on ethoxyquin as a preservative or antioxidant. Other chemical preservatives are: ascorbic acid, propionic acid, benzoic acid, citric acid and their various salts. There are technological problems (i.e., moisture level, etc.) associated with the use of these preservatives. Economics, however, remain the most important consideration which limit their use in fish foods.

A list of chemical preservatives appears in Table 1.

Table 1 Commonly Used Chemical Preservatives Generally Recognized as Safe

Ascorbic acid
Ascorbyl palmitate
Benzoic acid
BHA
BHT
Calcium ascorbate
Calcium propionate
Calcium sorbate
Citrate acid
Dilauryl thiodipropionate
Distearyl thiodipropionate
Erythorbic acid
Ethoxyquin
Formic acid
Methylparaben
Potassium bisulphite
Potassium metabisulphite
Potassium sorbate
Propionic acid
Propyl gallate
Propyl paraben
Resin guaiac
Sodium ascorbate
Sodium benzoate
Sodium bisulphite
Sodium metabisulphite
Sodium nitrite
Sodium propionate
Sodium sorbate
Sodium sulphite
Sorbic acid
Stannous chloride
Sulphur dioxide
THBP - Trihydroxy-butylphenone
TBHQ - Tertiary-butylhydroquinone
Thiodipinic acid
Tocopherols

4. FUNCTIONAL EFFECTS OF ANTIOXIDANTS

- [4.1 Nutrient Deficiency Prevention](#)
- [4.2 Prevention of Rancid Oxidation of Fats](#)

The functional effects of the antioxidants as they affect nutrients and the animals' utilization of them can be summarized as follows:

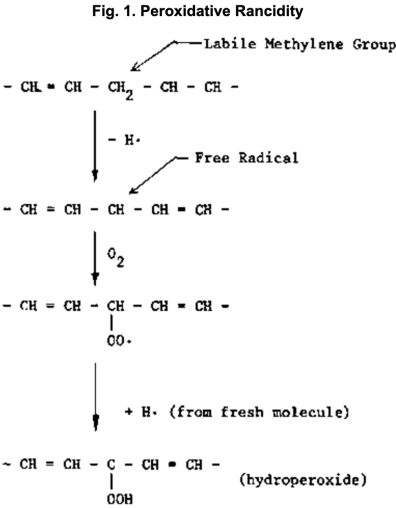
4.1 Nutrient Deficiency Prevention

Dietary deficiencies of vitamins A and E seem to be ameliorated in certain circumstances and ethoxyquin promotes higher levels of vitamin A storage in the liver. Repletion/deletion experiments show that in both monogastric and ruminant animals, a diet containing an anti-oxidant protects fat soluble vitamins throughout ingestion and metabolism. The important

benefit of antioxidants most probably lies in their conservation of essential nutrients and their improved utilization by the animal. Altogether too often, it is the practice to use levels of vitamin E far above the animals' nutrient requirement and the result is economically unfavourable. It has been shown in diets designed for chicken and turkey breeders that ethoxyquin has a vitamin E sparing effect.

4.2 Prevention of Rancid Oxidation of Fats

In lipid peroxidation, the unsaturated fatty acids undergo a loss of hydrogen, resulting in the formation of a free radical at the site of unsaturation. If the feed material in which this reaction is taking place does not contain vitamin E or some other effective antioxidant, the free radical is quickly converted to a fatty acid peroxide free radical and finally to a fatty acid hydroperoxide (Fig. 1). An antioxidant can block this peroxidation by supplying a hydrogen in the first free radical formed, thereby reconverting it to the original fatty acid. If the hydroperoxides are allowed to form, they continue to decompose by breaking down into a variety of aldehydes and ketones.



Antioxidants prevent oxidative losses of vitamins A and E and pigments (oxy- and keto-carotenoids) in stored mixed feeds. Antioxidants stabilize critical oxidation-susceptible nutrients that are naturally present in a fish feed composed of several feedstuffs so that losses are minimal from mixing and storing. If pigmenting substances are used, the antioxidants are definitely needed. The benefits of adequate, consistent use span all facets of fish production which include the processing and handling of feedstuffs, formulation, and fish cultural practices.

Some beneficial effects of ethoxyquin are described in Table 2.

Table 2 Some Effects of Ethoxyquin in Feeds

Sample	Vitamin A activity, I.U.*		Change (%)
Feed A (no antioxidant added)	Initial 150 325		
	Final 77 800		- 48.2
Feed B (150 ppm Ethoxyquin)	Initial 151 366		
	Final 115 633		- 23.6
Sample	Extractable fat*	Iodine No.*	ME (cal/lb)*
Fish meal (unstabilized)	7.0	109	1 149
Fish meal (stabilized)	9.4	178	1 461
Hatchability of eggs from hens (12 weeks, 7% linoleic acid diet)			
Supplementation		Egg hatchability (%)	
None		55.50	
Ethoxyquin, 125 ppm		78.96	
Vitamin E, 16 mg/lb		82.11	
Ethoxyquin, 125 ppm and Vitamin E, 16 mg/lb		79.15	

* Four month's storage

5. LEVEL OF ANTIOXIDANT USAGE IN FEED

The U.S. Food and Drug Administration permits the following levels of antioxidant in finished feed:

- (a) ethoxyquin (1,2 dihydro-6-ethoxy-2,2,4- trimethy quinoline): 150 ppm,
- (b) BHT (butylated hydroxytoluene): 200 ppm, and
- (c) BHA (butylated hydroxyanisole): 200 ppm.

6. OTHER EFFECTS OF ANTIOXIDANTS IN FEED

It was recently found that BHT, which is widely used as a poultry food additive, prevented mortality in chickens exposed to virulent Newcastle disease virus but prevented an antibody response when chickens were exposed to a virulent Newcastle disease virus. This *in vivo* effect of BHT in rations containing 100-150 ppm suggests a possible explanation for vaccination failure sometimes encountered with live vaccines and possibly a new direction in the development of antiviral therapy. Researchers are now trying to define the mechanism of the apparent antiviral action of BHT and extending their attention to other viruses using both BHT and other antioxidants.

