Effect of Artificial Drying on Tocopherols and Fatty Acids of Corn

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A study was conducted on the stability of the fatty acids and individual tocopherols in corn under several conditions of artificial drying. Samples of corn were dried at temperatures ranging from ambient to 290° F. until the moisture content was reduced from about 25 to 15%. No effect on either the fatty acid or vitamin E content was discernible.

Frequent reports have appeared in recent years of field outbreaks of vitamin E deficiency in monogastric farm animals fed rations composed predominantly of corn and soybean meal. In some cases a low intake of selenium (an element which reduces the vitamin E requirement) has been a complicating factor. In others, conditions conducive to vitamin E destruction in the grain may have prevailed, such as high moisture content, prolonged storage or overdrying.

Destruction of vitamin E during curing and storage of forages is well known. Brown (1953) reported losses of 25–45% in freshly cut grasses dried in a current of air at 105° C. for 45 minutes. Similar losses were found by Cabell and Ellis (1942) in grasses dried at 60° C. for 24 hours. Livingston *et al.* (1968) observed decreases of 54–73% in alfalfa during storage at 90° F. for 12 weeks and of 5–33% during commercial-scale dehydration. Herting and Drury (1963) found that storage of ground corn or the presence of mold was associated with significant decreases in vitamin E content, the greatest losses being incurred by the non-α-tocopherols. Moisture content is an important factor in the stability of tocopherols in feedstuffs. Thafvelin and Oksanen (1966) recorded a 60% loss of vitamin E within 4 days in high-moisture hay dried in a swath. Komoda and Harada (1969) have reported that the addition of water to raw soybeans resulted in extensive oxidation of tocopherols in 7 days.

The possible effect of artificial drying on the vitamin E content of corn apparently has not been investigated. Accordingly, a study was conducted on the stability of the various isomers of vitamin E in corn under several conditions of drying. As these isomers have different stability characteristics and biopotencies for animals, it is necessary to determine each individually in order to obtain an estimate of changes in total biological activity. Previous studies have revealed losses of fatty acids during drying and storage of hays (Van der Veen and Olcott, 1967; Thafvelin and Oksanen, 1966); hence the dried samples were also analyzed for these constituents.

MATERIALS AND METHODS

Samples of dried corn were kindly furnished by the Department of Agricultural Engineering. The conditions of artificial drying, summarized in Table I, were designed to reduce the moisture content from an initial value of approximately 25 to about 15%. All samples were derived from a freshly harvested crop of hybrid corn. Sample 2 was dried for 48 hours in a flow or forced air at ambient temperatures fluctuating from 36–60° F. The other samples were dried in a model fluidized bed drier and rapidly cooled at the end of the drying period. Sample 1 served as an undried reference sample.

Table I. Conditions Employed for Drying Corn Samples

Sample No.	Air Temp. (°F.)	Drying Time (hr.)	Maximum Kernel Temp. (°F.)
1	...	...	...
2	36–60[a]	48	60
3	90	7	90
4	140	2.5	135
5	190	1.2	180
6	240	0.8	190
7	290	0.5	220

[a] Ranges in temperatures of unheated forced air.

The dried samples were ground and extracted with acetone for 5 hours in a Soxhlet apparatus and the extract was evaporated to dryness *in vacuo* on a rotary evaporator at 40° C. Tocopherols were determined by the method of Chow *et al.* (1969). Samples of oil ranging from 210 to 330 mg. were dissolved in 50 volumes of acetone and immersed in a dry ice–acetone bath for 10 minutes. The crystallized lipids were filtered off at −70° C. with the aid of suction and washed five times with 30 volumes of precooled acetone. Evaporation of the filtrate left a residue amounting to 4 to 6% of the weight of the original oil. This procedure gives good recoveries of vitamin E and is designed to avoid the destruction of tocopherols (particularly the unsaturated isomers) which occurs during saponification.

The residue from the uncrystallizable fraction was purified in two successive thin-layer chromatographic systems as proposed by Pennock *et al.* (1964) using chloroform and 20% isopropyl ether in petroleum ether, respectively, as solvents. Silica gel G prepared with water containing 0.002% dichlorofluorescein served as the stationary phase. Standard saturated tocopherols (α-, β-, γ- and δ-T) were obtained from Distillation Products Industries, Rochester, N. Y. (The following abbreviations are used: α-T, β-T, γ-T, and δ-T are α-, β-, γ-, δ-tocopherol, respectively; α-T-3, β-T-3, γ-T-3, and δ-T-3 are the corresponding tocotrienols.) Tocotrienols (α-, β-, γ-, and δ-T-3) were obtained from natural sources for the preparation of standard curves and use as reference compounds during thin-layer chromatography: α-T-3 from barley; β-T-3 from wheat bran; γ-T-3 and δ-T-3 from latex. The tocopherols were located under ultraviolet light, eluted individually with peroxide-free ether and measured spectrophotometrically by the modified Emmerie-Engel procedure of Tsen (1961). A standard curve was prepared for each compound and a constant 3-minute reaction time was used for all.

Twenty to 40 mg. of oil was interesterified by refluxing in 4 ml. of 4% H_2SO_4 in methanol for 30 minutes. The com-

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Table II. Tocopherol and Fatty Acid Content of Dried Corn Samples

Sample	1	2	3	4	5	6	7
Total tocopherols (μg./G. oil)	1492	1562	1600	1681	1670	1585	1629
Tocopherol distribution (%)							
α-T	18	17	18	19	18	20	19
α-T-3	7	10	9	9	9	8	10
γ-T	61	57	58	56	57	58	58
γ-T-3	14	16	15	16	16	14	13
Fatty acid distribution (%)							
Palmitic	16.8	14.7	14.2	15.8	14.6	15.3	14.6
Stearic	0.2	0.5	0.3	0.4	0.1	0.2	0.5
Oleic	21.3	21.0	22.2	22.8	23.1	22.0	20.9
Linoleic	59.9	61.6	61.1	59.0	60.4	60.4	62.3
Linolenic	1.5	2.1	2.0	1.4	1.7	1.9	1.6
Unidentified	0.3	0.1	0.2	0.6	0.1	0.2	0.1

position of the fatty acid methyl esters was determined by gas-liquid chromatography (Beckman GC-4, 20% diethylene glycol succinate on Chromosorb W 80/100, column 1/4 inch × 6 foot, He flow 60 ml. per minute, temperature 180° C.).

RESULTS AND DISCUSSIONS

The distribution of tocopherols and fatty acids in the corn samples is shown in Table II. No differences were found in total vitamin E content or in the proportions of the four tocopherol isomers in the dried samples. Comparison of the data for samples 2 to 7 with those for the undried reference sample indicates that none of the drying conditions employed had any destructive effect on tocopherols. The slightly lower value for the total vitamin E content of the undried corn may reflect a less efficient extraction from the high moisture sample.

The variety of corn used for this study is noteworthy in having an unusually high proportion of tocotrienols (9% α-T-3 and 15% γ-T-3) and a low proportion of γ-T. A fresh sample of another variety contained 851 μg. of total vitamin E per gram of oil of which 83% consisted of γ-T. These observations illustrate the variability with respect to both the total vitamin E content and the distribution of tocopherols in the grain of this species.

The data in Table II also show that drying had no significant effect upon the fatty acid composition of the corn oil. This finding agrees with the results on vitamin E, as oxidation of unsaturated fatty acids would not be anticipated in the absence of tocopherol destruction. As well as being high in vitamin E, the oil of this variety contained an unusually high proportion of linoleic acid (Mehlenbacher, 1960). In contrast the oil of the miscellaneous variety which contained 851 μg. of vitamin E per gram contained only 51.2% linoleic acid. This may be a reflection of the general correlation between the degree of unsaturation of lipids in natural materials and their vitamin E content. It would be of interest to determine whether this relationship applies to varieties of corn representing a range of linoleic acid contents.

Artificial drying of corn can be effectively carried out without destruction of vitamin E or unsaturated fatty acids. It may be anticipated, however, that overdrying, particularly at high temperatures, will lead to decreases in the concentration of these nutrients in corn.

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