Technical Papers

Methionine—Origin of Sunlight Flavor in Milk[1]

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Exposure of milk to daylight, in conventional glass milk bottles, for periods of about ½ hr or more produces an objectionable flavor commonly known as "sunlight" or "activated" (*1–6*). Wavelengths of light in the visible spectrum are responsible for the flavor. Incident to its production, most of the ascorbic acid and a substantial part of the riboflavin in the milk are destroyed (*3, 4*). Therefore, sunlight flavor in milk has important economic and nutritional implications. Sulfur-containing compounds are associated with the flavor (*2, 5*) and a derived protein from heated whey will produce the flavor on exposure to sunlight (*2, 6*). Experiments at this laboratory have indicated that the flavor substance has its origin in methionine and that flavor production is dependent, in a large measure, on the presence of riboflavin.

In these experiments, all samples were exposed for 1 hr to sunlight of an intensity which varied between 400 and 600 Weston units. During exposure samples were retained in conventional flint glass, quart milk bottles. For each exposed sample an unexposed control was prepared and held in a refrigerator. Flavor was determined by three judges, experienced in the identity and evaluation of sunlight flavor.

The importance of methionine in sunlight flavor production first was suspected when exposure of dilute aqueous solutions of this amino acid was observed to develop a flavor apparently identical with that produced on exposing milk. Further study revealed that the addition of methionine in quantities as little as 4 mg/qt greatly enhanced production of the flavor in skim milk (Table 1). From these data it is evident that the flavor production mechanism can function independently of temperature. The readiness with which the flavor formed in skim milk as compared with pure solutions of methionine suggested that some milk constituent aids in flavor formation. In this regard, riboflavin was considered a logical possibility since it is the only skim milk component showing appreciable light absorption in the visible region. Distilled water solutions of methionine (20 mg/qt) and riboflavin (1.5 mg/qt) were prepared and exposed. The sample containing methionine developed a slight but noticeable degree of typical sunlight flavor, whereas that containing methionine and riboflavin developed the flavor to an extreme degree. The sample containing only riboflavin had no detectable flavor of any kind. It was noted with interest that the unexposed sample containing methionine and riboflavin developed some sunlight flavor during its preparation and storage in the refrigerator, a period of about 1.5 hr. This was the only instance in which any control sample exhibited a flavor remotely resembling that in question.

TABLE 1

EFFECT OF ADDED DL-METHIONINE ON THE DEVELOPMENT OF SUNLIGHT FLAVOR IN SKIM MILK*

Sample No.	Methionine added (mg/qt)	Exposure time (min)	Temperature after exposure of storage† (°C)	Flavor intensity‡
1	None	0	5°	0
2	None	60	8°	1
3	50	0	5°	0
4	4	60	8°	3
5	20	60	8°	4
6	50	60	8°	4+

* Exposed in conventional quart bottles to direct sunlight of 400 Weston units intensity.

† Outdoor temperature, 2° C, initial temperature of the milk 5° C.

‡ 0, no sunlight flavor; 1, slight; 2, medium; 3, strong; 4, very strong sunlight flavor.

It seemed of interest to determine whether other sulfur-containing amino acids, such as cysteine or cystine, would augment sunlight flavor in skim milk in the manner shown by methionine. These two amino acids and methionine were added separately to quart samples of skim milk at a rate of 20 mg/qt. The samples together with a control, containing no added amino acid, were exposed and then examined for flavor. The samples containing cysteine and cystine exhibited about the same degree of sunlight flavor as the control. The flavor was greatly intensified in the sample containing methionine. Thus the flavor appears to result rather specifically from photolysis of methionine. The specific nature of this interesting chemical change in an essential amino acid, which is activated by solar energy and intensified by the presence of a naturally occurring pigment, will be the subject of further investigation.

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