Effect of Light on Alteration of Nutritional Value and Flavor of Milk: A Review

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ABSTRACT

Milk in glass, polycarbonate, high density polyethylene, blow-molded polyethylene, plastic bags and cardboard containers, when exposed to fluorescent light or sunlight, will develop a characteristic off-flavor described synonymously by many researchers as activated, sunlight or oxidized flavor. The extent of flavor development is related to the exposure interval, strength of the light and amount of milk surface exposed. Cardboard containers, particularly those with large printed areas of dark ink or foil in the laminate, offer the best protection to milk, while the remaining containers offered limited protection at best. Characteristic flavor is produced principally by conversion of methionine to methional. Partial loss of vitamins B2 and C and some amino acids parallel development of light-induced off-flavor. Loss of other constituents is minimal. Many researchers offered suggestions to improve the flavor stability of milk held in display cases illuminated with fluorescent lights. Among these are changes to more protective packaging, reduction of radiant energy to 538 lux, use of gold or transparent or translucent containers, a further flavor cover and time of day. It is apparent from this literature that development of light-induced off-flavor is clearly a function of the amount of radiant energy at the milk surface and the length of exposure.

ALTERATION OF FLAVOR

Acceptance of milk as a food is based to a large extent on its flavor and shelf-life. Barnard (4) reported that the incidence of oxidized flavor in fluid milk was increasing rapidly. During a 4-year period, over 1,600 milk samples collected from 400 retail stores in Pennsylvania and representing 250 brands were analyzed by a trained taste panel. Initially, in 1967, only 6.7% of 210 samples analyzed were criticized for oxidized flavor. This percentage increased to 23.9% or 106 of 443 samples in 1970. To further illustrate the breadth of the oxidized flavor problem, a comparison was made of four major types of containers and the distribution of oxidized flavor: blow-molded plastic containers showed that 86.1% of milk contained was criticized as having an oxidized flavor, plastic bags showed 50.0% glass bottles showed 46.4%, and the least was plastic coated paper with 12.7% having oxidized milk (4). It is apparent from this literature that development of light-induced off-flavor is clearly a function of the amount of radiant energy at the milk surface and the length of exposure.

Amount and source of light necessary to produce flavor alteration

When the effect of light on milk flavor was first observed, sunlight was the only energy source that induced this oxidized or activated flavor. Needless to say, accurate measurement of sunlight intensity was difficult since it varied with season, geographic location, cloud cover and time of day. Holmes and Jones (26) used a pyrheliometer to record and control its intensity. Other more recent researchers have attempted to correlate the intensity of fluorescent light with the development of objectionable oxidized flavor. Dunkley et al. (16) showed that oxidized flavor development was a function of exposure time and distance from the light source. Using two 40-watt Cool White (F40CW) fluorescent lamps, 1.22 m long, and 1 quart clear flint glass bottles, they proved that exposure time for comparable light activated flavor in milk was 5 to 6 times longer at a distance of 30.5 cm from the light source than at 1.3 cm. Data showed similar and perceptible activated flavor developed in 20 to 40 min at 1.3 cm from the light and 2 to 4 h at a distance of 30.5 cm.

Bradfield and Duthie (8) reported variations in light intensities from 215-5380 lux in display cases in...
Vermont, while de Man (13) stated that fluorescent light intensities in supermarket display cases in Guelph and Toronto, Canada varied from 550-5500 lux with many in the range of 1000 to 3000 lux. In another study, the average light intensity in display cases in 105 supermarkets was 2001 lux (2). Hedrick and Glass (22) attempted to simulate average conditions in a grocery store display case, using fluorescent light adjusted in energy output to 1614 lux and positioned with 5.1 cm from the top of milk containers. Intensity of this magnitude caused changes in flavor and composition after milk was exposed for 5 h in both paperboard and blow-molded plastic gallon containers. In a similar test, Dimick (14) used a retail milk display case illuminated by cool white fluorescent lamps (F40CW) mounted parallel to the shelves and 45.7 cm from the containers. Illumination as measured with a Weston illumination meter averaged 1076 lux at a position perpendicular to the light source and at the midpoint of the exposed vertical surface of the container. He used paperboard (unprinted, paper-coated paper and 0.58 mm thickness), blow-molded polyethylene (55 g and 0.52 mm thickness) and clear flint glass (2.5 mm thickness) half-gallon containers with each type of container having 185 to 190 cm² of surface area exposed to the light. Average light transmission in these experiments was 2.8% for paperboard, 69.2% for plastic and 90.7% for glass containers. Subsequently, flavor comparisons were made using a trained panel of 12 women. After 12 h of exposure all containers of milk were rated lower than was unexposed control milk. Flavor of milk stored in plastic and glass containers was similar and decreased markedly in acceptance after 12 h of exposure, while milk in paperboard containers required exposure to the light source for 48 h to reach similar flavor ratings.

In a second experiment, Hoskin and Dimick (27) evaluated the ability of returnable polycarbonate, tinted polycarbonate, high density polyethylene, flint glass containers and nonreturnable unprinted paperboard carbons to protect homogenized milk from activated flavor development. After 12 h of exposure to cool white fluorescent lamps (F40CW) producing 1076 ± 50 lux at the vertical container surface, significant differences in milk flavor scores were apparent. Milk held in paperboard containers had hedonic flavor ratings showing no difference statistically to non-illuminated control milk. Milk in glass, high density polyethylene and non-tinted polycarbonate containers was afforded little protection, while milk held in polycarbonate containers tinted with a blocking material effective against energy in the 380-480 nm region had hedonic flavor ratings intermediate to those given for milk in paperboard and for milk in glass, etc.

As little exposure time as 10 min will produce a discernable activated flavor (26). However, intensity of off-flavor diminished with prolonged exposure (26). Presumably, this is attributed to decomposition of methional developed during subsequent and prolonged exposure to light.

One solution (3) was to minimize the amount of lighting in retail cabinets to an intensity of 538 lux. An alternative was to use gold or “bug light” fluorescent lights in display cabinets (16).

Chemical changes occurring to exhibits this flavor

Many attempts have been made to identify the characteristic flavor compounds in milk having a sunlight or activated flavor. Weinstein and Trout concluded that a protein in heat-treated whey would produce the characteristic flavor (48). Shortly after this report, Patton and Josephson (35) showed that the amino acid, methionine, was responsible for activated flavor in milk. Using a pure solution of methionine, they detected a flavor after sunlight-exposure similar to that observed in skim milk also exposed to sunlight.

Samuelsson and Harper (36) demonstrated the role of Strecker degradation in converting methionine into methional, ammonia and carbon dioxide. Vitamin B₀ and oxygen are needed in this reaction. Moreover, they suggested that free amino acids were also necessary for this reaction. McLaren (32) found that 45 kcal/mol were required to split the peptide linkage to free amino acids. In the visible region of the light spectrum, energy available is 71 to 95.3 kcal/mol, which is more than sufficient. Further, McLaren showed that 58 kcal/mol were necessary to split a C-S bond to form a mercaptan. Using this evidence (32), Samuelsson and Harper (36) proceeded to demonstrate the possible formation of methional, hydrogen sulfide, formaldehyde, acetaldehyde, propional and various combinations of hydrocarbon substituents on sulphydryl, sulfide and disulfide bases. However, Cohen and Ojanpera (11) indicated that the phoreduction of methionine at pH 7 produced methional with a 100%-yield.

Additional evidence showed that methionine was oxidized to methional in presence of direct sunlight (1) and the proposed mechanism by which this reaction proceeded (11). Prolonged exposure to sunlight produced such obnoxious flavor compounds as methyl mercaptan. It is apparent from this research that factors responsible for the degree of off-flavor are three-fold: intensity of the light source, duration of exposure and compounds generated (1).

Singleton et al. (41) suspected that a component of relatively large molecular weight rather than methional was responsible for the flavor. Speculation occurred because of a nondialyzable component found in skim milk following addition of riboflavin and exposure to sunlight. In a model system containing tryptophan and riboflavin, a complex was formed upon exposure to light which was the suspected flavor component. Moreover, Bassette (5) confirmed the effect of light on production of some volatile compounds in milk exposed to sunlight. He found increases in compounds which normally comprise the flavor in milk, such as acetaldehyde, propanal, methyl sulfide, acetone, butanone, n-pentanal and n-hexanal. Apparently the precursor to acetaldehyde is
in the nonfat portion while precursors to other carbonyl compounds are found in the lipid phase.

Threshold of flavor perception

Patton stated that the threshold for perception of methional, the principal entity in sunlight flavor, was 50 parts per billion (34). In skim milk there is 1.3 to 4.3 µm of free methionine per liter which represents a potential for methional of 3 to 9 times the taste threshold.

Effect of processing variables on development of flavor

Raw milk is more susceptible to development of sunlight flavor than milk that has been thermally processed (43). Weinstein and Trout (47) showed that heating milk to 80 C and holding for 5 min did not affect development of sunlight flavor. However, they did observe that sunlight flavor tended to destroy the heated flavor.

One would anticipate that the freeing of sulphydryl groups in whey proteins by excessive heat treatment would reduce the rate of development of this off-flavor since these sulphydryls are highly sensitive to and readily combine with oxygen. In fact, this practice of high heat treatment has been used for decades to retard onset of oxidized flavor in susceptible and high-fat dairy foods.

Before using vitamin concentrates to fortify milk with vitamin D, irradiation with ultra-violet light was practiced. “Irradiation flavor” was found to be the result of using early equipment (10). Weckel and Jackson (45) first reported this flavor as a part of their historically significant efforts to produce Vitamin D-fortified milk by irradiation using carbon arc lamps. Later, Flake et al. (18) isolated a sulfur-containing material thought to be the material responsible for the off-flavor.

Homogenization increases the susceptibility of milk to oxidized flavor and this has been reported by many (17, 24, 47). Also, in excess of 95% of fluid milk sold in the United States currently is homogenized.

Influence of the wavelength of light

Sunlight flavor was an important defect in milk irradiated to increase its vitamin D content. Flake et al. (17) studied the effect of different wavelengths of light and showed that elimination of wavelengths below 460 nm reduced the rate at which activated flavor developed. Later, Herreid et al. (25) found that ruby glass gave almost complete protection against sunlight flavor development since no radiant energy below 600 nm was transmitted through the glass. In addition, the rate of development of activated flavor is reduced in those retail cabinets equipped with yellow fluorescent lights or fluorescent lights with yellow shields. Radiation spectra of these lighting systems show minimal energy emitted below a wavelength of 540 nm.

Influence of milk temperature

In two different experiments, Dunkley et al. (16) proved that higher milk temperatures increase the intensity of the light flavor. Using temperatures of 0 and 11 C and later 1 and 16 C, they identified that the flavor problem was attributed to both a faster reaction rate and a more intense exposure.

Effect of storage time on flavor intensity

One of the greatest contributions to development of activated flavor is the length of storage in illuminated cabinets or in sunlight. In some vertical dairy cases, there are locations from which milk containers are seldom removed, for example, toward the back and center part. Milk containers in these areas are sold, in general, only when moved elsewhere in the cabinet (8). Also, in the low, reach-in variety of retail cabinet, the front row of cartons may not be sold for long periods, while containers in rows 2 and 3 were generally removed at a much faster rate. For example, in three stores examined by Bradfield and Duthie (8), half-gallon milk containers in row 1 disappeared in the amount of 27%, while similarly sized containers in rows 2 and 3 disappeared in amounts of 32 and 22%, respectively. On the other hand, quarts disappeared from row 1 in the amount of 16%; row 2, 25%; and row 3, 20%. Rows of both quart and half-gallon containers further back in these cabinets were sold more slowly.

In an in-depth study published by Market Facts of New York (2), 105 retail milk outlets were evaluated for disappearance of milk from cabinets as a means of assessing the length of exposure to fluorescent lighting in these display cabinets. The average light intensity in these stores was 2001 lux. In 15 outlets in each of 6 cities, using time-marked milk containers, they found 71% of these containers unsold after 5 h, 58% unsold after 8 h and 37% unsold after 24 h regardless of container size or type. The study involved use of 58,973 marked containers.

Dunkley et al. (16) found that 2 days of storage in the dark followed by exposure to a known amount of radiant energy resulted in less activated flavor than did a similar exposure immediately following processing. These researchers had no explanations for this effect.

EFFECT OF MILK CONTAINER ON OFF-FLAVOR DEVELOPMENT

The type of container used to hold milk between processing and consumption is extremely critical in minimizing flavor and nutrient alteration. Considered in this section will be glass, returnable high density polyethylene, returnable polycarbonate, blow-molded polyethylene, paper board and plastic bag containers.

Glass

In 1920, Hammer and Cordes (17) suggested that brown-colored glass milk bottles were effective in preventing the action of light on milk. Later, Herreid et al. (22) showed that amber glass offered protection from light for intervals up to 30 min, whereas ruby glass containers offered the best protection of all containers, including paper. Ruby glass permitted minimal light transmission in wavelengths less than 600 nm. These researchers found that milk taken from pasture-grazed
cows showed no activated flavor in ruby glass containers after 2 h in direct sunlight. On the other hand, milk in amber bottles showed only slight off-flavor after 30 min in sunlight. In all trials to determine the protective effect offered by various colors of glass, comparisons made to clear glass indicated that it offered virtually no protection from the actinic rays of the sun or fluorescent light. The lack of or negligible protective effect offered by clear glass has been reported by numerous authors (14,16,22,25,37,42 and 49). In fact, Henderson et al. (24) found sunlight flavor in milk exposed 10 min in the sun at noon. In the 380 to 480 nm critical region, glass containers (3.4 mm wall thickness) showed 95% energy transmission (27).

Because of the problem of sunlight flavor in milk, many retail home delivery companies formerly supplied consumers with insulated metal boxes to preclude action of the sun’s radiant energy. In the 1930's, little off-flavor was observed in creamline type of milk. Later, homogenization became widely practiced and the problem surfaced to a substantial degree. Colored or tinted bottles were used by some dairies in an attempt to alleviate the flavor problem. However, very few dairies, if any, used ruby glass because of cost; most used amber bottles. The amount of protection offered even by amber glass was insufficient and their use waned.

**Blow-molded single service polyethylene container**

Single-service, plastic containers allow some additional protection from sunlight because of the opacity of the plastic. Dimick (14), using blow-molded half-gallon containers 55 g and with 0.52 mm wall thickness, found that homogenized milk developed off-flavor attributed to light at a rate close to that of milk in glass containers. An expert taste panel ranked milk exposed to fluorescent light in glass and blow-molded plastic containers for 12 and 24 h as “dislike slightly” with a hedonic rating of 4.0. The panels used a 9-point hedonic rating system.

Barnard (4) indicated that single-service plastic containers provide little more protection for milk to the actinic effect of light than glass. In a survey of market milk conducted in 1970, 86.1% or 31 of 36 samples in blow-molded plastic were oxidized. A similar result, 84.2%, was indicated in sampling in 1973. Blow-molded plastic containers permit 25 to 50% of the light to pass through the wall. Plastic 3-quad milk containers allow 60% light transmission at 400 nm and over 80% at 700 nm. Some solutions were offered to reduce transmission; add such materials as titanium dioxide, talc, and other agents to block visible light. However, de Man (13) recently showed the negligible effect of using titanium dioxide in bottle matrix.

Hansen et al. (21) established that homogenized milk in blow-molded plastic containers in a simulated display case showed sunlight flavor after 2 to 4 h of exposure to 2152 lux of energy produced by 40-watt Cool White fluorescent lamps 6.4 cm from the containers. Barnard et al. (3) found an increased time, 5 to 8 h, to develop sunlight flavor when the lamp intensity was 1937 lux, while Dimick (14), using 1076 lux of fluorescent light, found homogenized milk in blow-molded containers with sunlight flavor after 12 h of exposure.

**Paperboard containers**

Of all materials used for single service milk containers, paperboard best protects milk’s flavor and nutritional qualities. It is not without fault, as reported. However, some researchers offer suggestions to yet improve the light absorption and reflection.

Henderson et al. (24) first studied the effects of sunlight on milk in different types of paperboard containers. They used (a) white bleached paper, the thinnest of the three types; (b) cream colored paper of intermediate thickness; and (c) multiple layers of bleached white outer plies and unbleached and light brown inner plies, the thickest of the three paperboards considered. These paperboards were paraffined, which should be similar to the current paperboard which is polyethylene-coated. A Weston photometer placed behind the paperboard exposed to direct sunlight gave readings of a-400, b-180 and c-80. All paperboards used in this study were much superior to glass. Milk stored in cartons made from material (a) yielded a slight sunlight flavor in 1 h in noon sun, milk in carton (c) showed none, while milk in carton (b) was scored intermediate for off-flavor but showed no sunlight flavor.

Unprinted portions of commercial milk cartons differed markedly in amount of light transmission (11,13). Ink used absorbs light energy, dependent upon the color of the ink. The conclusion reached from this effort was that cartons should be designed with large areas of red, brown, black, yellow or orange inks to absorb the shorter wavelengths of energy. This is particularly true of the top or gable of the carton. Bradfield and Duthie (6,7) reported values for light energy transmitted through paperboard colored with red, blue, black and green inks. With an uncolored paperboard carton established as 100% transmission reference, using a 4304 lux fluorescent light then red gave 54% transmission, blue 27%, black 27% and green 18%. Bradfield and Duthie (6,7) stated that milk in uncolored cartons exposed to 2376-2690 lux of fluorescent light changed flavor in 54 h. At 4304 lux, milk in the uncolored cartons developed sunlight flavor in 12 to 18 h. When a green carton was used, the time for onset of the off-flavor was 18-24 h (7). Sattar and de Man (37) showed that light transmission values for paperboard containers at 400 nm was 0% and about 13% at 700 nm. Printing on the carton reduced energy transmission values to 0 to 10%.

It is apparent that any paperboard laminate that contains an aluminum foil layer, such as used for long life dairy products, would minimize the amount of light transmitted and increase the flavor shelf-life of the product contained.

**Plastic bags**

It is questionable whether this type of container should
be considered principally for such reasons as: number for individual consumer use, uncertainty of the presence of
an outer protective cardboard box, i.e., "bag-in-box" container and the mechanism or manner of storage. Barnard (3)
gave the only data with no mention of any outer wrap. In this study, 50% of samples in plastic bags 
(6 of 12) were oxidized. This value is comparable to that for oxidized off-flavor in milk in glass, 46.4% or 26 of 56 samples.

Returnable high density polyethylene and polycarbonate containers

These milk containers are relatively new and have shown limited consumer appeal. Hoskin and Dimick (27) showed that gallon-sized, high density polyethylene milk containers with a 1.7-mm wall thickness allowed transmission of 58% of fluorescent light, as measured using a Westron model 756 meter. Gallon-sized polycarbonate milk containers with a 1.5-mm wall thickness allowed 90% transmission while those polycarbonate containers structured with energy-blocking material allowed 75% transmission through a 1.5-mm wall.

EFFECT OF CONTAINER TYPE ON CHANGE IN COMPOSITION OF OTHER MILK CONSTITUENTS

In consideration of the direct effect of light on flavor of milk, it is apparent that effects on other milk constituents would be proportional and related to wavelength, intensity and duration of exposure to light.

Riboflavin

In sunlight and fluorescent light, loss of riboflavin in milk is rapid. Herreid et al. (25) indicated that in 30 min as much as 30% of riboflavin in milk was destroyed with this going to 80% in 2 h of exposure to sunlight. Singleton et al. (41), in a similar study, showed 64% loss of riboflavin in 30 min of exposure to sunlight and 89% loss after 2 h. Degradation followed first order kinetics and the rate increased directly with temperature (39). Amber bottles gave complete protection and prevented destruction of riboflavin.

Since the rate of destruction of riboflavin is related directly to milk temperature as well as the amount of light transmitted through the container, greater loss would occur in summer months when product temperature generally would be higher (42). Dunkley et al. (16) showed that destruction of riboflavin in milk retail cabinets was directly related to the wavelength and wattage or food candles of energy. Riboflavin is most labile when exposed to radiant energy between 415 and 455 nm (39). At wavelengths above 550 nm, destruction of riboflavin was markedly reduced (16). Further, light-activated flavor was induced by light of more wavelengths than that absorbed by riboflavin. Josephson (28) showed that light above 550 nm contributed to off-flavor, while Dunkley et al. (16) proved that wavelengths less than 550 nm were responsible for loss of riboflavin. Sattar and de Man (37) indicated that the most damaging wavelengths are 350-500 nm. The use of a gold lamp or "bug light" color would be one solution to control of both off-flavor and vitamin destruction in milk stored in retail cabinets (16). Maniere and Dimick (31) showed that the rate of riboflavin destruction increased when it was in a free form and unassociated with the proteins or fat in milk. A recent study (33) chemically defined the major degradation product of riboflavin as lumichrome.

Ascorbic acid

Milk nutritionally is not noted as a significant source of vitamin C. Ascorbic acid is rapidly oxidized to dehydroascorbic acid and this reaction is accelerated in the presence of light (44). The rate of destruction of vitamin C is proportional to the amount of light transmitted through the container, the wavelength of that energy (25) and the presence of riboflavin (40).

Henderson et al. (24) indicated that brown or amber glass and paperboard containers offer the greatest protection from the actinic rays of radiant energy. Using paperboard containers with different light opacities, they showed that vitamin C destruction was proportional to light transmission and was indirectly related to flavor development. Hedrick and Glass (22) showed similar results using paperboard and blow-molded plastic milk containers.

Woessner et al. (49) showed that ascorbic acid was stable during normal thermal processing operations but disappeared rapidly during light exposure. Dunkley and others (16) analyzed the active wavelengths of light that would destroy ascorbic acid. They showed that energy between 400 and 550 nm was responsible. As with riboflavin, the greatest protective effect in illuminated retail cabinets would be from gold or "bug light" type lamps.

Amino acids and proteins

Dimick (14,15) showed that even though the sunlight flavor was attributed to oxidation of the essential amino acid, methionine, no significant change occurred in its concentration or the concentration of 16 other amino acids over a period of 144 h when milk in paperboard, blow-molded plastic and glass containers was exposed to fluorescent light. Singleton et al. (41) and Gregory et al. (19) found that the amount of tryptophan decreased on exposure of milk to light and this loss was directly related to loss of riboflavin and indirectly related to sunlight flavor intensity. After 2 h of exposure to sunlight about 15% of the tryptophan disappeared. Cysteine, histidine, methionine, tryptophan and tyrosine are principally susceptible to photosensitized oxidation (2).

It is possible that photodegradation of isolated milk protein fractions may occur (29,30,46). Both low and high molecular weight serum proteins are involved as substrates.

Vitamin A and β-carotene

Sattar et al. (38) showed that loss of vitamin A and its precursor could be markedly reduced by limiting
exposure of milk to energy below 465 nm. Destruction was not autocatalytic and followed zero-order kinetics. No synergism was observed except that at β-carotene concentrations of greater than 2.5 μg/ml a protective effect on vitamin A was observed.

FLAVOR EVALUATION BY TASTE PANELS

Coleman et al. described the problem best (1,2). In most light flavor research, trained or expert panels use the official A.D.S.C. score card for milk, making it difficult to compare consumer acceptability of light-activated flavor. In their study, experts initially flavor-scored milk, then a panel of trained tasters was used, followed by mass sampling by untrained people to assess their ability to discriminate light-activated flavor. The consumer taste panel of 781 people (15-25 years old) rated three samples of milk, one exposed to 1076 lux of fluorescent light at 7 C for 12 h, a second sample exposed similarly for 24 h and the third sample was a non-light exposed control sample. A 5-point hedonic scale was used by 391 panelists ranking acceptance as control-best, then the milks exposed 12 and 24 h, respectively. A similar placing resulted when the remaining 390 panelists used a ranking procedure. Coleman et al. (1,2) showed that paperboard is the most acceptable container for milk. However, the consumer is only able to differentiate the flavor of milk samples when comparisons are made. Further, consumers might not object to the off-flavor unless comparison samples are available. Bray et al. (9) confirmed these results in a 200 heterogeneous consumer survey. Furthermore, no significant difference was found between age groups (a-younger than 25; b-younger than 25) in ability to distinguish oxidized milk from non-exposed control milk; however, in all groups, females showed a better ability to distinguish between the two samples offered than did males.

REFERENCES


IDF Report, con't from p. 335

original statement discussing additional assessments was deleted. In the future, a draft will be prepared as to the cost of membership when the U.S. decided to become a formal member of IDF.

The participants at the meeting agreed to pay the $100.00 membership fee. The treasurer was authorized to open an account and have the necessary stationery printed. This money will be used to honor vouchers for expenses accrued in operation of the Interim Committee.

The obtaining of operating funds for a permanent committee was reviewed and it was recommended that at this point, no government funds be solicited but an attempt could be made to obtain some financing from various foundations.

Respectfully submitted.

Harold Wainess
IAMFES Representative
International Dairy Federation

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Proposed Functioning of an Interim United States National Committee of the International Dairy Federation

1. The name of the organization shall be the "Interim National Committee of IDF in the USA."
2. The Committee shall be the member organization for the United States of America in the International Dairy Federation until December 31, 1980. IDF membership fee shall be waived for this period.
3. The purposes and objectives of the Committee are:
   a. to assess the need for a permanent United States National Committee of IDF;
   b. to provide a means of representation for those likely to benefit from or contribute to the purpose and activities of the IDF and of the Committee;
   c. to organize effective United States participation in and contribution to the work of the IDF;
   d. to provide effective communication and utilization in the United States of the results of the work and activities of the IDF;
4. The members of the Committee shall be persons involved in the United States dairy industry interested in the objectives and purposes of the Committee and of the IDF.
   a. Membership may be on a personal basis, or as a representative of an organization, institution or association.
   b. Members shall pay an initial fee of $100.
   c. A prospective member shall, upon written notice and payment of initial fee to the Committee Secretary, become a member for the duration of the Committee's existence.
5. The Committee shall select a Chairman, a Secretary who will be responsible for communication between the IDF and Committee members, a Treasurer, and any other officers necessary to further the objectives and purposes of the Committee.
6. Meetings of the Committee shall be held from time to time at the call of the Chairman which all members are entitled to attend. Proceedings of all meetings shall be communicated to members.
7. Liaison advisory groups may be named by the Committee. These groups shall consist of members and or non-members who represent various institutions, organizations, associations, or government and whose views and expertise will further the objectives and purposes of the Committee.
8. The disbursement of funds of the Committee shall be made in furtherance of the objectives and purposes of the Committee. Expenses incurred in participation at any meeting of the Committee, liaison advisory groups or of the IDF by any individual shall be paid by that individual or his organization, unless otherwise indicated by the Committee.
9. United States participation in the work and activities of the IDF or any of its Commissions shall be under the direction of the Committee.
10. Commission representatives shall be expert advisors to the Committee who may represent the Committee at IDF meetings, act as Chairman of ad hoc subcommittees and otherwise assist the Committee.
11. Bylaws may be adopted or amended at any meeting of the Committee provided thirty days notice has been provided and a copy of the proposed amendment has been included with the notice.
12. The Committee shall issue a report no later than April 1, 1981 reviewing its previous work and its assessment of the need for an official, permanent United States National Committee of IDF.

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