A STUDY OF THE ABSORPTION OF ODORS BY MILK

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INTRODUCTION

There are numerous ways by which flavors may gain entrance into or develop in milk. These generally include feed, absorption of odors from the air, physiological disturbances of the cow, bacterial growth and chemical activity induced by sunlight, metallic salts or enzymes.

Perhaps the most common or best known of the off-flavors of milk are those associated with feed. Many studies have been made and much data collected on this type of flavor, showing largely the relation of time of feeding to the off-flavor in the milk. Feed flavors are so common that many dairymen and even control officers believe that direct absorption of feed flavors by milk after it has been drawn plays an important role in clean-flavored milk production.

Data on the direct absorption of odors by milk under various conditions are rather limited. The purpose of this study was to ascertain under what conditions odoriferous substances enter milk through direct absorption and to compare the rate and intensity of directly absorbed off-odors in milk with those which gain entrance to milk through the body of the cow.

REVIEW OF LITERATURE

Classification of origin of milk flavors

Harding, Rogers and Smith (1900) stated that on the basis of origin there were two general classes of flavors, those directly connected with the growth of plant life in the milk and those associated with compounds taken up while in the cow or absorbed after the milk was drawn.

In general, Marshall (1902), Weld (1909), and Gamble and Kelly (1922) classified the origin of flavors and odors of milk as follows:

a. The physiological condition of the cow.

b. The absorption within the body of the cow of odors from highly odoriferous feeds.

c. The direct absorption of odors after the milk was drawn.

d. Bacterial development within the milk upon standing.

In addition to the above classification of origin of milk flavors Mackintosh (1929), Pien and Herschdoerfer (1935), and Olsen (1938) added those resulting from chemical changes in milk due to sunlight, metallic salts or enzymic action.

Sharp (1941), on the other hand, lists six general causes of off-flavor in milk which are as follows:

"1. microbial growth and decomposition.
 2. feed.
 3. absorbed.
 4. chemical composition of the milk.
 5. processing and handling.
 6. enzymatic and catalytic changes."

The normal flavor of milk

While many descriptive terms of off-flavors of milk are to be found in the literature, those describing the normal flavor of milk are rather limited. However, several descriptions of normal flavor of milk are given.

Pearson (1896), and Fleischmann (1896) stated that normal milk had a slight pleasant odor and a rich distinctly sweetish taste. Winslow (1907) described milk as having, "a peculiar, pleasant odor and taste which cannot be described."

Hastings' (1926) description of milk flavors follows: "The fresh clean product of a healthy well fed cow is almost devoid of taste and smell, so completely so that it can be used daily with constant satisfication. The more nearly the milk retains its original properties, the greater will it attract the consumer and the more it will be used to the ultimate good of all."

Van Slyke (1927) explained that, "Perfect flavor in market milk is indicated by freedom from all traces of abnormal odor and taste. There should be no marked odor and no trace of any offensive smell. The taste should be palatable, slightly saline, and rich without any unpalatable aftertaste. It should not be flat or insipid."

Trout (1932) believed that, "Normal whole milk is pleasantly sweet, possessing neither a foretaste nor an aftertaste other than that imparted by the natural richness of the milk."

Eckles, Combes and Macy (1936) concluded that milk had no pronounced taste but was slightly sweet to most persons. Milk freshly

drawn had a characteristic flavor which was quite volatile and soon disappeared when the milk was exposed to the air.

Thus, it would seem that the tendency exists to describe the flavor of normal milk in negative terms, that is, what flavors should not be present, rather than in positive terms.

External absorption of odors

Harley (1829) noted that when milk came into contact with foreign substances or impure air the taste and smell was impaired and stated that milk was even tainted simply by drawing it from the cow to a pitcher in foul air. Thus he believed that barns should be well ventilated to avoid odors in the milk.

Russell (1897) stated, "Many liquids have a great affinity for matter in a gaseous form and will absorb varying amounts of such substances. These can be readily recognized if the absorbed substances contains an odoriferous principle. A fluid milk possesses this property to an unusual degree for not only does liquid serum absorb volatile odors, but the fat also has a great affinity for many of these substances."

The opinion was current that milk warmer than the surrounding atmosphere gave off odors and only milk cooler than the surrounding air took on odors. Russell (1897) disproved this theory. Furthermore, he (1898) found that the odor was greater in the warm milk as shown by the following data.

Relative absorption of odors in warm and cold milk.

Kind of odor	Time of exposure	No. of tests made	No. of tests with stronger odors in	
			Warm milk	Cold milk
Corn silage	1 hour	5	5	
	3 hours	3	2	1
	5 hours	2	2	
Horse manure	¼ hour	3	1	
	1 hour	3	2	
	1½ hours	2	2	
	2 hours	2	2	
Oil cinnamon	1 hour	6	5	
	2½ hours	2	2	
	3 hours	3	3	

Relative absorption of odors in warm and cold milk.

Kind of odor	Time of exposure	No. of tests made	No. of tests with stronger ordors in		Ave. range in temperature Milk ° F.		Ave. temp. of air ° F.
			Warm milk	Cold milk	Warm milk	Cold milk	
Oil cassia Cinnamon	½ hour	20	12	7	83	52	70
	1 hour	20	15	5			
	1½ hours	20	12	5			
Oil of winter-green	½ hour	16	13	3	90	57	68
	1 hour	16	14	2			
	1½ hours	16	16				
Oil of pepper-winter	½ hour	12	12		72	49	65
	1 hour	12	11	1			
	1½ hours	12	12				
Horse mamure	½ hour	3	3		83	45	70
	1 hour	3	2				
	1½ hours	3	3				
Urine of cow	½ hour	8	7		82	44	69
	1 hour	8	8				
	1½ hours	8	8				

King and Farrington (1897) demonstrated that odors were more readily absorbed in warm than in cold milk. They pointed out that although silage odors were absorbed by the milk the odors in the milk were less intense than those in the milk obtained by feeding silage just before milking.

Ritland (1899) working with the turnipy taste of milk conducted the following experiment, "Two cows which were on pasturage were fed turnips out of doors and milked in the stable, and later they were fed hay and turnips in the stable and milked out of doors, the object being to test the absorption of the turnipy odor. No grain was fed at any time. The amount of turnips fed was as high as 1 hectoliter (2.84 bu.) per cow daily. Tests of the milk at different times by a number of persons failed to reveal any turnipy taste in the milk. The conclusion is reached that the characteristic taste often observed when turnips are fed is due entirely to the absorption by the milk of the volatile ingredients of the turnips."

Dombrowsky (1904), working with absorption of odors by goats' milk, found thar odors of iodoform and anise were taken up readily and held for some time while those of carbolic acid, turpentine and formalin were taken up and lost quickly. The odor of chloride of lime was only feebly absorbed.

Bordas and Touplain (1906) exposed milk for several minutes in an atmosphere of 1 to 100,000 parts of formaldehyde. They found that the fresher the milk the more rapid was the absorption.

Yaxis (1917) demonstrated the absorption of odors in cream by placing the odoriferous substances onto a cheese cloth directly over

the cream. He found that the odor of onions, garlic, cabbage, turnips and corn silage were all readily absorbed. When higher temperatures and longer periods of exposure were used, the off odors of the cream were stronger. Exposure to gasoline, kerosene and creolin resulted in distinct odors in the cream. Oils of peppermint and wintergreen produced stronger odors in cream than did oil of cinnamon.

Gamble and Kelly (1922) allowed warm milk to flow through a closed chamber saturated with silage odor. The milk took on a decided silage odor. However, under controlled and adequate experiments, they later demonstrated and concluded that direct absorption of silage odors during milking were of minor importance.

Alt (1926) exposed milk at different temperatures to air which had been passed through bovine urine. He found that the fat of milk was largely responsible for the absorption of the foreign odor.

Lea (1933) cited work of Gane's as follows: "Gane has carried out some investigations on the absorption by butterfat of d-limonene ($C_{10}H_{16}$) which is the chief constituent of the oil of orange-ring. The avidity with which this strongly odorous substance is taken up from the air by a free surface of fat is as follows: --- "

Temperature	20	10	5	0	-10	-20
Vapour-pressure of limonene (mm.Hg.)	1.01	0.54	0.39	0.33	0.17	0.08
Lomonene absorbed (mg. per 100 sq. cm. per min.)	3.60	1.76	0.96	0.59	0.18	0.08
Ratio of rate of absorption of vapour-pressure	3.57	3.26	2.46	1.78	1.08	0.96

When solid butterfat was exposed to limonene for a period of 14 days in a saturated atmosphere only the outmost one mm. of fat absorbed the odor.

Roadhouse and Henderson (1935) noted that milk readily absorbed odors from paint, coal-tar disinfectants, gasoline, kerosene, some fly sprays, and tobacco smoke. The amount absorbed depended on the efficiency of ventilation.

Hammer (1938) stated, "The practice of pouring bottled milk into a shallow pan and allowing it to stand so that it can be skimmed easily is especially objectionable, not only from the standpoint of contamination but also because it permits the rapid absorption of odors of other food products placed near the milk."

Babcock (1939) well summarized the importance of direct absorption of odors by milk in the following statement: "The absorption of odors as a source of abnormal flavors in milk has been over-emphasized. Experimental work has shown that even under extreme conditions milk produced in a silage permeated atmosphere was seldom sufficiently tainted so that a silage flavor could be detected in the milk. If under extreme conditions sufficient silage is not absorbed so that it can be identified in the milk it appears as though we should encounter but little trouble from this source when milk is produced under normal conditions."

Internal absorption of odors

Many data are available concerning the effect of various feeds and feeding practices on the taste and smell of milk. The few citations presented here show that the internal absorption of odors have a profound

effect on the flavor of milk unless precautions in dairy herd management are taken to prevent flavor impairment.

King and Farrington (1897) believed that when a cow ate any substance which contained a volatile principle this substance would be removed from the blood by the various channels of excretion. When these substances were circulated in the blood in a cow's body and she was being milked, then some of the volatile substances would be removed in the milk which would cause an abnormal flavor and odor. If sufficient time had passed between feeding volatile substances and milking such products would have been removed from the blood by the skin, lungs, and kidneys and the milk drawn would be normal.

Fleischmann (1896) recommended that putrifying food of any kind should not be fed to dairy cows. He found that beans, peas, pea-straw and barley-straw should not be fed to milk cows while good grass, hay, grains, especially oats and wheat bran, produced milk without taints.

Marchal (1926) treated grain with p-dichlorobenzene and fed it to cattle, resulting in a slight modification of the flavor of the milk.

Procter (1926) found that when cattle ate Mayweed a taint was produced in the milk. An extract was prepared by mixing two pounds of Mayweed in water and given to the cow in the evening. The milk next morning showed a faint Mayweed taint.

The California Agricultural Experiment Station (1931) conducted the following experiment with alfalfa juice. "Four cows were drenched with the juice expressed from 25 pounds of green alfalfa. This quantity of alfalfa yielded 5 to 6 quarts of juice. It required from 3½ to 5 minutes for two people to administer this quantity of liquid. The cows

were partially milked in some cases every 5 minutes for the first 30 minutes, and in other cases at the end of 45 minutes, 1 hour and 2 hours after drenching. It was found that feed flavor could be definitely detected in the milk 20 minutes after drenching. The most prominent flavor was present in the milk drawn between 45 and 60 minutes after drenching. The 2-hour samples were less prominent in feed flavors than were the samples drawn 1-hour after drenching."

Babcock's numerous experiments (1923-a), (1923-b), (1924), (1924-b) and (1927) show conclusively that feed and time of feeding with respect to milking have a marked effect on the flavor of the resulting milk. Even when the cows were permitted to breathe odoriferous substances without ingesting them (1925-a), the characteristic odor was present in the milk within two minutes after cows inhaled garlic for ten minutes.

For a substance to pass through the digestive system before entering the milk requires considerable time. Moore (1939) showed experimentally that when a rich carotene feed such as freshly cut alfalfa was fed to cattle, 15 hours were required before the blood plasma of the cow showed a slight increase in its carotene content.

Some fundamentals of gas absorption by liquids

Laws relating to absorption of gases by liquids would seem to be applicable in some respects to absorption of odors in milk.

According to Henry's law the concentration of the dissolved gas in solution is directly proportional to the concentration in the free space above the liquid or $\frac{C}{P} = K$, where K is called the solubility co-efficient and is defined as the ratio of concentration of dissolved gas

C to the pressure of the gas P. The extent which a gas would dissolve would depend on the pressure, the temperature, the nature of the gas, and the nature of the solvent.

Whitman (1923) held that diffusion occurred through a gas film and was caused by the partial pressure differences of the solute in the gas and that it was in equilibrium with the liquid of the film.

Becker (1924) found that when a liquid and a moderately soluble gas were allowed to come in contact, and the liquid kept uniform in composition, the rate of solution of the gas would vary directly as the degree of unsaturation of the liquid. Becker has shown experimentally the absorption of oxygen and nitrogen in air-free water by allowing the gas to bubble up through a tube filled with air-free water and measuring the reduction in pressure of the bubble due to the absorption of a portion of the gas. Many factors affected the absorption of a gas by stationary water depending upon, the gas, its density, surface tension, viscosity, and temperature. It was found that carbon dioxide, hydrogen, and hydrogen sulfide saturate the surface layers of the water while nitrous oxide, nitric oxide, and chlorine do not form saturated surface layers and are therefore absorbed at a greater rate. The effect of dissolved gas on the density of the water is to increase it while the surface tension and the viscosity tend to maintain the surface in its original condition. It was found that sometimes the rate of solution was greatly affected by slight disturbances of the liquid.

Whitman and Davis (1924) studying the absorption rates of four gases found that the absorption rates for sulfur dioxide, oxygen, ammonia, and hydrochloric acid could be predicted with an accuracy of 15 per cent or better.

Hatta (1933) found that the velocity of absorption was increased by about 30 per cent per 10° C. rise in temperature and when the film of liquid was thin, the velocity was inversely proportional to the thickness and almost independent of change in composition of the liquid.

Higbie (1934) showed experimentally that as the time of exposure was decreased, the rate of absorption or the coefficient did not increase indefinitely as predicted by the penetration theory. He found there was a maximum or initial rate of absorption which was approached by shortening the time of exposure, and agitating beyond a certain degree was useless in the absorption of carbon dioxide in water.

Thus it would appear that the solubility of gases in liquids is limited. The extent to which a gas dissolves in a substance such as milk apparently depends upon the pressure, the surface tension, the temperature, and the nature of the gas. As previously stated Lea (1933) citing Gane's work stated that when there was a decrease in vapour-pressure and temperature, the rate of absorption would also decrease.

EXPERIMENTAL

The different types of milk were obtained from the Creamery, of the Department of Dairy Husbandry, Michigan State College. The raw milk was secured from a vat full of milk ready to be pasturized. The homogenized and pasteurized milks were obtained from the same milk after processing. The heated milk was processed by heating to 170° F. for five minutes and cooling immediately to the desired temperature in order to inhibit creaming.

After the milk was tempered for exposure, 50 ml. samples of milk were placed in small ground glass, low wide form, weighing bottles with covers ground to match. Six of these bottles were placed in a desiccator. Four desiccators were used in each trial with a different type of milk placed in each. The desiccators were placed in the ante-room of an ice cream storage room at a temperature of 50° F. and in an incubator at 100° F. The desiccators and milk were at the desired temperature before the odoriferous substance was placed in them. The odoriferous substance was placed in a small beaker and the glass bottles placed around the beaker. Enough of the odoriferous substance was used so that the milk would be exposed to a saturated atmosphere. When identical amounts of the same odoriferous substance were placed in each desiccator the covers were removed from the weighing bottles.

The different types of milk were then exposed for 15 minute periods ranging from 15 to 90 minutes. Each different odor under study was run at 50° F. and at 100° F. to compare the absorptive power of different types of milk when the fat was in a liquid and in a solid state. After exposure

the bottles were examined and then placed in the ante-room at 50° F. for 24-hours. Before final grading of the samples for odor intensity the milk was tempered to room temperature. Each glass weighing bottle had an identification number. These bottles were shuffled and graded into groups by smell according to intensity of odor by two judges. All judging was done "blind". The room in which judging was done was free from all odors. The intensity of odors were deisgnated as follows:

? = doubtful

\+ = slight odor

\+ + = pronounced odor

\+ + + = very pronounced odor

which for practical purposes in making up the tables and graphs were called 1, 2, 3, and 4, respectively.

Two chlorine-phenol solutions were made up as follows: Solution A - three grams of B-K and three grams of phenol crystals were dissolved in 94 ml. of water; Solution B - four grams of B-K and two grams of phenol crystals in the same amount of water. The five per cent phenol solution was made up by dissolving five grams of phenol in 95 ml. of water. The phenol crystals were obtained from J. T. Baker's Chemical Company, Phillipsburg, New Jersey.

The different types of milk were exposed to different essential oils, namely, those of cinnamon, dillweed, lemon, orange, peppermint, turpentine, and wintergreen. These oils were obtained from Will Corporation, Rochester, New York. Magnus, Mable & Reynard, Importers, New York City imported certain of the above oils for the Will Corporation.

Corn silage was taken from the silo and placed in an air-tight container. As the silo from which the grass silage was obtained did not have a roof, the silage was taken from a considerable depth below the surface in order to secure a representative sample having a full odor.

Fifty ml. of the different types of milk were placed in the glass weighing bottles and exposed to each of the following seven substances: bacon, banana, cabbage, onion, orange, potatoes, and turnips. These foods were cut up so that the odoriferous substance contained therein could more easily saturate the atmosphere in the desiccator. The cabbage was exposed to the milk in both the raw and cooked form. The potatoes were left unwashed in one case and were washed in another. The turnips were exposed only in the cooked form. The desiccators and milks were placed in the ante-room of an ice cream storage room at a temperature of 50° F. and another trial set was run at room temperature. The samples were exposed to the above substances for a period of 1 and 24-hours. Immediately after the one-hour exposure the samples were examined for identification of the odoriferous substance and for odor intensity. The one-hour trial samples were placed in the ante-room at 50° F. until the 24-hour exposure samples were to be graded. All the samples were tempered to room temperature and then were examined for identification of the odoriferous substance and for odor intensity.

Fresh warm milk having no abnormal odor was obtained from Jersey cow No. 88, at the Dairy Barn, was divided into lots, and was exposed to different surroundings for one and one-half hours. One-half

pint samples were placed in six inch culture dishes at the following locations:

Calf pen
Milk room
Inside corn silo
Gutter which contained manure
Feed room
Feed alley
Barn ventilator exit
Corn silo alleyway
Bull pen
Shavings bin
Stall adjacent to a rumen fistula cow
Inside grass silo without roof.

After the exposure period 50 ml. of the milk was strained through cheesecloth, to remove particles of dirt which had fallen into certain of these dishes, into glass weighing bottles and covered immediately. The weighing bottles were taken to the laboratory and examined for odor intensity.

One-half pint samples of fresh warm milk also from cow No. 88 were placed in the six-inch culture dishes and exposed to the atmosphere in the corn and grass silos for 15 minute periods ranging from 15 to 90 minutes. The corn silo was nearly empty and contained quite a pronounced odor while the grass silage was exposed to the weather and was quite dried out. After the exposure period the samples were strained through cheesecloth into the weighing bottles, covered immediately, and examined in the laboratory for intensity of odor.

Eighty pounds of pasteurized milk in a specially fitted ten-gallon milk can was exposed for one hour to grass silage and turpentine wrapped or soaked in a cheesecloth on the underside of the can cover. In both cases the amount of grass silage used was 130 grams. Milk was drawn from the bottom of the can in ten eight-pound lots. Care was taken not to jar or shake the can so that the different layers of milk would not be mixed. Trials were run with the milk fat in a liquid and in a solid state. The samples were then graded according to the intensity of the contaminating odor.

Different odoriferous substances were placed in gelatin capsules and given to Holstein cows No. 274 and 287. The capsules were made air-tight by sealing them with parafilm manufactured by the Menasha Products Company, Menasha, Wisconsin. The gelatin capsules with the odoriferous substance were placed in warm water of 102° F. to find out approximately the time necessary to dissolve the gelatin capsule and thus release the odoriferous substance. The gelatin capsules were forced down the cow's throat by a capsule gun. Samples of milk were obtained before giving the cow the odoriferous substance and at one-fourth, one-half, 1, 8, 16, 24, 32, 40, and 48 hours after the capsules were administered. At certain of these intervals her breath was noted. When the cow urinated the smell was noted to find out whether the odoriferous substance had been passed off in the urine.

RESULTS

The relative absorption of odors by milk subjected to various treatments when exposed to saturated atmospheres.

Samples of heated, homogenized, pasteurized, and raw milk were exposed at 50° F. and at 100° F. to saturated atmospheres of various odoriferous substances from 15 to 90 minutes and examined for odor immediately after the experiment and after 24 hours. The data are summarized in table 1.

The results secured indicate that the different milks vary in their absorptive capacity to take up the odoriferous substances. The milk with the fat in a liquid state absorbed the odoriferous substances faster as well as in greater quantities than when the fat was in a solid state. However, some discrepancies and inconsistencies of absorption of the different substances were noted. In general, exposures of milk to saturated atmospheres of odoriferous substances required 30 minutes or longer before pronounced odors were detectable in the milk.

Table 1. The relative absorption of odors in milk subjected to different processes when exposed to saturated atmospheres for various periods of time at 50° F. and at 100° F.

Odoriferous substance	Treatment of milk	Relative absorption of odors by milk when exposed at 50° F. and at 100° F.													
		0	15	30	45	60	75	90	0	15	30	45	60	75	90
Chlorine-phenol solution A (avg. 2 trials)	Heated	0	1.0	1.5	2.0	2.5	3.0	3.5	0	0	2.5	2.0	3.5	3.5	4.0
	Homo.	0	0.0	1.5	2.0	2.0	2.5	3.0	0	0	2.0	1.0	1.0	2.5	3.0
	Past.	0	1.0	2.0	2.0	2.5	3.0	4.0	0	0	1.0	2.5	3.0	3.0	3.5
	Raw	0	2.0	2.0	2.0	3.5	4.0	4.0	0	3.0	4.0	4.0	3.5	4.0	4.0
Chlorine-phenol solution B (avg. 2 trials)	Heated	0	0	1.0	2.0	2.0	2.5	3.0	0	0.5	1.5	2.0	2.0	3.0	3.5
	Homo.	0	0.5	1.5	2.0	2.0	2.0	3.0	0	0.5	0.0	2.0	2.0	2.0	3.0
	Past.	0	1.0	2.0	2.0	2.5	3.0	3.5	0	0.0	1.5	2.0	2.0	3.0	3.0
	Raw	0	2.0	2.0	2.0	2.5	3.0	4.0	0	2.0	2.5	2.5	3.0	4.0	4.0
Cinnamon, oil of (avg. 3 trials)	Heated	0	0.3	2.0	2.0	2.0	3.0	3.3	0	2.0	2.6	3.0	3.0	3.0	3.3
	Homo.	0	0	1.6	2.0	2.0	2.0	2.0	0	0	2.0	2.0	2.0	2.0	3.0
	Past.	0	0	2.0	2.3	2.6	3.0	3.6	0	2.0	3.0	3.0	3.0	4.0	4.0
	Raw	0	1.3	2.0	2.0	2.0	3.0	3.0	0	2.0	2.0	3.0	3.0	3.0	4.0
Cow manure (fresh) (avg. 2-4 trials)	Heated	0	0	0	0	0.5	0.5	0.5	0	4.0	4.0	4.0	4.0	4.0	4.0
	Homo.	0	0	0	1.0	2.0	2.5	2.5	0	2.0	3.0	4.0	4.0	4.0	4.0
	Past.	0	0	2.0	2.0	3.0	3.0	4.0	0	4.0	4.0	4.0	4.0	4.0	4.0
	Raw	0	0	1.5	2.0	2.0	3.0	3.0	0	4.0	4.0	4.0	4.0	4.0	4.0
Cow manure (liquid) (avg. 2 trials)	Heated	0	1.0	1.0	2.0	3.0	3.0	4.0	0	1.5	2.0	3.0	4.0	4.0	4.0
	Homo.	0	2.0	3.0	3.0	4.0	4.0	4.0	0	3.0	3.5	4.0	4.0	4.0	4.0
	Past.	0	2.0	3.0	4.0	4.0	4.0	4.0	0	4.0	4.0	4.0	4.0	4.0	4.0
	Raw	0	2.0	3.0	3.0	4.0	4.0	4.0	0	2.0	3.0	4.0	4.0	4.0	4.0
Dillweed, oil of (avg. 3 trials)	Heated	0	2.0	2.0	2.0	2.0	2.0	2.6	0	2.0	2.0	3.0	3.0	4.0	4.0
	Homo.	0	2.0	2.0	3.0	3.0	3.0	3.3	0	2.0	3.0	3.0	2.6	3.0	4.0
	Past.	0	2.0	3.0	3.3	4.0	4.0	4.0	0	2.0	3.0	3.0	3.0	4.0	4.0
	Raw	0	1.6	2.0	2.0	3.0	3.0	4.0	0	2.0	2.0	2.0	3.0	3.3	4.0

Table 1 continued

Odoriferous substance	Treatment of milk	Relative absorption of odors by milk when exposed at 50° F. and at 100° F. 0	15	30	45	60	75	90	0	15	30	45	60	75	90
Formaldehyde (avg. 2 trials)	Heated	0	0	1.0	2.0	2.0	2.5	3.0	0	1.0	2.0	2.0	2.5	3.0	3.0
	Homo.	0	0	1.0	1.5	2.0	3.0	3.0	0	0	1.0	2.0	2.0	2.5	3.0
	Past.	0	1.0	2.0	2.0	2.5	3.0	3.5	0	1.0	2.0	2.0	3.0	3.0	3.0
	Raw	0	1.0	2.0	2.0	2.5	3.0	3.0	0	1.0	2.0	2.0	3.0	3.0	3.0
Iodoform (powdered) (avg. 3 trials)	Heated	0	0	0	0	0	0.3	2.0	0	0	0	0	0	0.6	0.6
	Homo.	0	0	0	0	0	1.0	2.0	0	0	1.0	0.6	2.0	2.0	2.3
	Past.	0	0	0	0	0	1.0	2.0	0	0	0.3	0.6	2.0	2.6	3.0
	Raw	0	0	0	0	0	0	2.0	0	0.3	0	0	0.3	1.3	2.0
Lemon, oil of (avg. 3 trials)	Heated	0	0	0.3	1.0	0.3	1.6	2.0	0	2.0	2.0	3.3	4.0	4.0	4.0
	Homo.	0	2.0	2.3	2.6	3.0	3.6	4.0	0	2.0	2.0	3.0	3.0	3.0	3.3
	Past.	0	2.0	3.0	3.0	3.6	4.0	4.0	0	1.6	2.0	3.0	3.0	3.3	4.0
	Raw	0	0	0	0	1.6	2.0	2.0	0	1.0	2.0	3.0	3.6	4.0	4.0
Orange, oil of (avg. 2-3 trials)	Heated	0	0.5	2.0	2.0	2.0	2.0	3.0	0	0	1.6	2.0	2.0	3.0	3.0
	Homo.	0	0	2.0	2.0	2.0	2.0	3.0	0	0.6	1.3	2.0	2.0	3.0	3.0
	Past.	0	0	2.0	2.5	3.0	3.0	3.0	0	1.0	2.0	2.3	2.6	3.3	4.0
	Raw	0	0	2.0	2.0	2.0	3.0	3.0	0	1.0	2.0	2.0	2.0	3.0	4.0
Peppermint, oil of (avg. 2 trials)	Heated	0	2.0	2.0	2.0	2.0	2.5	3.0	0	2.0	2.0	2.0	2.0	2.0	3.0
	Homo.	0	2.0	3.0	3.0	3.0	3.0	4.0	0	2.0	2.0	3.0	3.0	3.0	4.0
	Past.	0	2.0	3.0	3.5	4.0	4.0	4.0	0	2.0	3.0	3.0	3.5	4.0	4.0
	Raw	0	2.0	2.0	2.5	2.5	3.0	3.0	0	2.0	2.5	3.0	3.0	4.0	4.0
Phenol solution (5 %) (avg. 2 trials)	Heated	0	0	0	0	0	0	0.5	0	0	0	0	0	0	0
	Homo.	0	0	0	0	0	0	0.5	0	0	0	0.5	0.5	0.5	1.5
	Past.	0	0	0	0	0	0	1.0	0	0	0	0.5	1.5	2.0	2.0
	Raw	0	0	0	0	0	0	0	0	0	0	0	0	0	1.5

Table 1 continued

Odoriferous substance	Treatment of milk	Relative absorption of odors by milk when exposed at 50° F. and at 100° F.													
		0	15	30	45	60	75	90	0	15	30	45	60	75	90
Silage (corn) (avg. 3 trials)	Heated	0	1.0	2.0	2.3	3.0	3.3	4.0	0	1.0	2.0	3.0	4.0	4.0	4.0
	Homo.	0	1.0	1.0	2.0	2.6	3.0	3.0	0	2.6	3.0	4.0	4.0	4.0	4.0
	Past.	0	1.0	2.0	2.6	3.3	3.3	4.0	0	2.6	3.6	4.0	4.0	4.0	4.0
	Raw	0	1.0	2.3	2.3	3.0	3.3	4.0	0	2.0	3.0	4.0	4.0	4.0	4.0
Silage (grass) (avg. 3 trials)	Heated	0	1.3	2.0	2.3	3.0	3.3	4.0	0	3.0	3.3	4.0	4.0	4.0	4.0
	Homo.	0	1.0	2.0	2.0	3.0	3.0	3.3	0	2.6	3.0	4.0	4.0	4.0	4.0
	Past.	0	1.3	2.0	2.6	3.0	3.3	4.0	0	3.0	4.0	4.0	4.0	4.0	4.0
	Raw	0	1.3	2.0	2.6	3.0	3.3	4.0	0	3.0	4.0	4.0	4.0	4.0	4.0
Turpentine, oil of (avg. 3-4 trials)	Heated	0	1.0	1.0	2.3	2.6	3.3	3.3	0	1.6	1.6	2.6	2.6	3.0	3.0
	Homo.	0	0	1.0	1.3	1.0	2.6	2.6	0	0.5	0.5	1.0	2.0	1.5	2.5
	Past.	0	0.6	1.3	1.3	2.0	3.0	3.6	0	0.5	2.5	3.0	3.5	3.5	3.5
	Raw	0	1.0	1.6	3.0	3.3	3.6	3.6	0	2.0	3.0	3.3	3.3	3.3	4.0
Urine (fresh) (avg. 2 trials)	Heated	0	1.0	2.0	2.0	2.0	2.5	3.0	0	2.0	2.0	3.0	3.0	3.5	4.0
	Homo.	0	2.0	2.0	3.0	3.0	3.0	4.0	0	2.0	2.0	3.0	3.0	4.0	4.0
	Past.	0	2.0	2.0	3.0	3.5	4.0	4.0	0	2.5	3.0	3.0	4.0	4.0	4.0
	Raw	0	1.5	2.0	2.0	2.5	3.0	3.0	0	2.0	2.0	2.5	3.0	3.0	4.0
Wintergreen, oil of (avg. 2 trials)	Heated	0	0	0	1.0	2.0	2.5	2.5	0	0	0	3.0	3.0	2.5	3.0
	Homo.	0	0	0	2.0	2.0	2.5	3.5	0	0	0	0	0	0.5	2.0
	Past.	0	2.0	2.0	3.0	3.0	4.0	4.0	0	0	0	1.5	1.5	2.0	1.5
	Raw	0	0	0	0	1.0	2.5	3.0	0	0	0	0	2.0	2.0	2.0

1. Absorption of chlorine-phenol and phenol odors

In comparing the absorptive quality of the different milks to the chlorine-phenol solutions, it was found that the odor of the solution A which was relatively richer in phenol than solution B was absorbed to a greater extent than that of solution B. Especially was this pronounced in the heated milk at 50° F. It will be noted that in homogenized, pasteurized, and raw milks there was very little difference in intensity of odor absorbed. At the 100° F. exposure heated, pasteurized, and especially raw milk absorbed the odor of solution A in greater intensity than solution B while homogenized milk absorbed slightly less of the odor of solution A.

When milk was exposed at 50° F. to the five per cent phenol solution the odor was absorbed only after an exposure of 90 minutes. Heated and homogenized milk contained this odor in only one trial after being exposed for 90 minutes while pasteurized milk absorbed this odor slightly in both trials. Raw milk failed to pick up this delicate odor. Heated milk at the 100° F. exposure failed to pick up this odor. Homogenized and pasteurized milks first picked up this odor after an exposure of 45 minutes while raw milk absorbed the odor only after an exposure of 90 minutes. From these trials it would indicate that the different milks did not absorb the phenol odor readily unless in chemical combination or mixture with chlorine.

2. Absorption of odors of essential oils

The intensity of absorbed odors in milks from the different essential oils when exposed from 15 to 90 minutes is shown in table 2.

Table 2. The relative absorption of odors in milk when exposed to essential oils for various periods of time at 50° F. and at 100° F.

Odoriferous substance	50° F.							100° F.						
	15	30	45	60	75	90	avg.	15	30	45	60	75	90	avg.
Exposure (min.) of heated milk at														
Cinnamon	0.3	2.0	2.0	2.0	3.0	3.3	2.11	2.0	2.6	3.0	3.0	3.0	3.3	2.83
Dillweed	2.0	2.0	2.0	2.0	2.0	2.6	2.11	2.0	2.0	3.0	3.0	4.0	4.0	3.00
Lemon	0.0	0.3	1.0	0.3	1.6	2.0	0.88	2.0	2.0	3.3	4.0	4.0	4.0	3.22
Orange	0.5	2.0	2.0	2.0	2.0	3.0	1.91	0.0	1.6	2.0	2.0	3.0	3.0	1.94
Peppermint	2.0	2.0	2.0	2.0	2.5	3.0	2.25	2.0	2.0	2.0	2.0	2.0	3.0	2.16
Turpentine	1.0	1.0	2.3	2.6	3.3	3.3	2.26	1.6	1.6	2.6	2.6	3.0	3.0	2.44
Wintergreen	0.0	0.0	1.0	2.0	2.5	2.5	1.33	0.0	0.0	3.0	3.0	2.5	3.0	1.91
Exposure (min.) of homogenized milk at	50°F.							100° F.						
Cinnamon	0.0	1.6	2.0	2.0	2.0	2.0	1.61	0.0	2.0	2.0	2.0	2.0	3.0	1.83
Dillweed	2.0	2.0	3.0	3.0	3.0	3.3	2.72	2.0	3.0	3.0	2.6	3.0	4.0	2.94
Lemon	2.0	2.3	2.6	3.0	3.6	4.0	2.94	2.0	2.0	3.0	3.0	3.0	3.3	2.72
Orange	0.0	2.0	2.0	2.0	2.0	3.0	1.83	0.6	1.3	2.0	2.0	2.0	3.0	1.83
Peppermint	2.0	3.0	3.0	3.0	3.0	4.0	3.00	2.0	2.0	3.0	3.0	3.0	4.0	2.83
Turpentine	0.0	1.0	1.3	1.0	2.6	2.6	1.44	0.5	0.5	1.0	2.0	1.5	2.5	1.33
Wintergreen	0.0	0.0	2.0	2.0	2.5	3.5	1.66	0.0	0.0	0.0	0.0	0.5	2.0	0.41
Exposure (min.) of pasteurized milk at	50° F.							100° F.						
Cinnamon	0.0	2.0	2.3	2.6	3.0	3.6	2.26	2.0	3.0	3.0	3.0	4.0	4.0	3.16
Dillweed	2.0	3.0	3.3	4.0	4.0	4.0	3.33	2.0	3.0	3.0	3.0	4.0	4.0	3.16
Lemon	2.0	3.0	3.0	3.6	4.0	4.0	3.27	1.6	2.0	3.0	3.0	3.3	4.0	2.83
Orange	0.0	2.0	2.5	3.0	3.0	3.0	2.25	1.0	2.0	2.3	2.6	3.3	4.0	2.55
Peppermint	2.0	3.0	3.5	4.0	4.0	4.0	3.41	2.0	3.0	3.0	3.5	4.0	4.0	3.25
Turpentine	0.6	1.3	1.3	2.0	3.0	3.6	2.00	0.5	2.5	3.0	3.5	3.5	3.5	2.73
Wintergreen	2.0	2.0	3.0	3.0	4.0	4.0	3.00	0.0	0.0	1.5	1.5	2.0	1.5	1.08
Exposure (min.) of raw milk at	50° F.							100° F.						
Cinnamon	1.3	2.0	2.0	2.0	3.0	3.0	2.22	2.0	2.0	3.0	3.0	3.0	4.0	2.83
Dillweed	1.6	2.0	2.0	3.0	3.0	4.0	2.61	2.0	2.0	2.0	3.0	3.3	4.0	2.72
Lemon	0.0	0.0	0.0	1.6	2.0	2.0	0.94	1.0	2.0	3.0	3.6	4.0	4.0	2.94
Orange	0.0	2.0	2.0	2.0	2.0	3.0	2.00	1.0	2.0	2.0	2.0	3.0	4.0	2.33
Peppermint	2.0	2.0	2.5	2.5	3.0	3.0	2.50	2.0	2.5	3.0	3.0	4.0	4.0	3.08
Turpentine	1.0	1.6	3.0	3.3	3.6	3.6	2.72	2.0	3.0	3.3	3.3	3.3	4.0	3.16
Wintergreen	0.0	0.0	0.0	1.0	2.5	3.0	1.09	0.0	0.0	0.0	2.0	2.0	2.0	1.00

The odor absorbed in greated intensity by the different milks at 50° F. and at 100° F. when exposed to the seven different essential oils is shown in table 3.

Table 3. Predominating odor absorbed by the different milks in greatest intensity when exposed at 50° F. and at 100° F.

Type of milk	Predominating odor in milk when exposed at 50° F.	100° F.
Heated	Turpentine	Lemon
Homogenzied	Peppermint	Dillweed
Pasteurized	Peppermint	Peppermint
Raw	Turpentine	Turpentine

The order of intensity of odor when the different types of milk were exposed at 50° F. and at 100° F. to the essential oils follows in table 4.

Table 4. The relative absorptive capacities of the different milks when exposed to essential oils at 50° F. and at 100° F.

Types of milk	Relative absorptive capacities of milk when exposed at 50° F.	100° F.
Heated	Turpentine, peppermint, cinnamon, dillweed, orange, wintergreen and lemon	Lemon, dillweed, cinnamon, turpentine, peppermint, orange and wintergreen
Homogenized	Peppermint, lemon, dillweed, orange, wintergreen, cinnamon and turpentine	Dillweed, peppermint, lemon, orange, cinnamon, turpentine, and wintergreen.
Pasteurized	Peppermint, dillweed, lemon, wintergreen, cinnamon, orange and turpentine	Peppermint, cinnamon, dillweed, lemon, turpentine, orange and wintergreen
Raw	Turpentine, dillweed, peppermint, cinnamon, orange, wintergreen and lemon	Turpentine, peppermint, lemon, cinnamon, dillweed, orange and wintergreen

Yaxis (1917) found oils of peppermint and wintergreen produced stronger flavors and odors in cream than oil of cinnamon. In the above experiment with milk at 50° F. oils of peppermint and cinnamon produced stronger odors than oil of wintergreen in heated, homogenized and raw milk while in pasteurized milk wintergreen was slightly stronger than oil of cinnamon. With the different milks at 100° F. exposure oil of wintergreen was much less in intensity.

Although the oils of cinnamon and wintergreen contained quite an odoriferous odor, the milks did not pick up the odor of these two substances as readily as some of the other essential oils. Taking the average of the four milks at 50° F. the order of intensity of absorbed odors was found to be oil of peppermint, dillweed, turpentine, cinnamon, lemon, orange and wintergreen. At the 100° F. exposure the order of intensity was essentially the same, being oil of dillweed, lemon, peppermint, cinnamon, turpentine, orange and wintergreen.

3. Absorption of cow manure and urine odors

When the different types of milk were exposed to fresh and liquid cow manure at 50° F. it was shown definitely that the odor of liquid manure was absorbed in greater intensity than that of the fresh manure. In this experiment the odor in certain cases was intensely absorbed. At the 100° F. exposure the odor of the fresh cow manure was absorbed in considerably greater quantities by heated, pasteurized and raw milk than that of the liquid manure while homogenized milk under 45 minutes exposure absorbed more of the liquid cow manure.

When fresh urine was exposed to the different milks, pasteurized milk absorbed the greater odor at both 50° F. and 100° F. followed by the

homogenized milk. Raw milk absorbed more intense odors at 50° F. and less odors at 100° F. than heated milk.

4. Absorption of formaldehyde and iodoform odors

Formaldehyde was not absorbed as intensely as certain of the essential oils or the odor from liquid cow manure. At exposures of 50° F. the formaldehyde odor was found to be greater in pasteurized followed by raw, heated and homogenized milk. At 100° F. the pasteurized and raw milks showed the same intensity of odor and heated and homogenized milk had slightly less odor. At both 50° F. and 100° F. exposures the pasteurized milk absorbed the more intense odor while homogenized milk absorbed the least of all the types of milk tested.

Three trials were run exposing powdered iodoform to the different milks. The odor of this substance was not readily absorbed at 50° F. but at 100° F. the intensity of the odor increased somewhat. At the 50° F. exposure no odor was detected in any of the milks until exposed for 75 minutes. At 90 minutes the intensity of the odor absorbed was equal in all types. When the different milks were exposed at 100° F. the homogenized and pasteurized milk showed an odor of iodoform after 30 minutes exposure. The results with raw milk were somewhat irregular. In one trial the odor was detected at 15 minutes. In the other trial with this type of milk the odor was not detected until 60 minutes and in all cases a marked odor was only detected at 75 minutes. Heated milk did not absorb this odor until exposed for 75 minutes. Pasteurized milk absorbed the more intense odor followed in order of intensity by homogenized, raw and heated milk.

5. Absorption of silage odors

The different milks were placed in desiccators containing corn and grass silage to determine which type of silage odor could be absorbed faster and also to find out which type of milk absorbed the more intense odor. In comparing the odor intensity at the 50° F. exposure, heated, homogenized and raw milks absorbed slightly more grass silage odor than that of corn silage while the intensity in the pasteurized milk was the same in both cases. At the 100° F. exposure pasteurized and raw milk absorbed more grass silage odor than corn silage odor. This was especially pronounced in the heated milk. In both cases homogenized milk absorbed the same odor intensity.

When the milks were exposed to corn silage at 50° F., pasteurized milk absorbed the greater odor intensity followed by raw, heated and homogenized milk. At the 100° F. exposure pasteurized milk still absorbed the greater odor intensity followed by homogenized, raw and heated milk. With the 50° F. exposure to grass silage, pasteurized and raw milks absorbed the same amount of odor followed closely by heated and homogenized milk. At 100° F. pasteurized and raw milk absorbed the same odor intensity followed very closely by heated and homogenized milk.

When the different intensities of the several odors were averaged, it was found, as shown in figures 1 and 2, that at 50° F. exposure, pasteurized milk absorbed the more intense odor followed in order by raw, homogenized, and heated milk. At 100° F. pasteurized milk still absorbed the most odor up to the 75 minute exposure. At the 90 minute exposure raw milk showed a greater absorption of odor than did pasteurized milk. At this temperature also, homogenized milk absorbed more intense odors than the heated milk.

The data presented in figure 3 indicated that the various milks absorbed more odor when the fat was in a liquid state than when in a solid state.

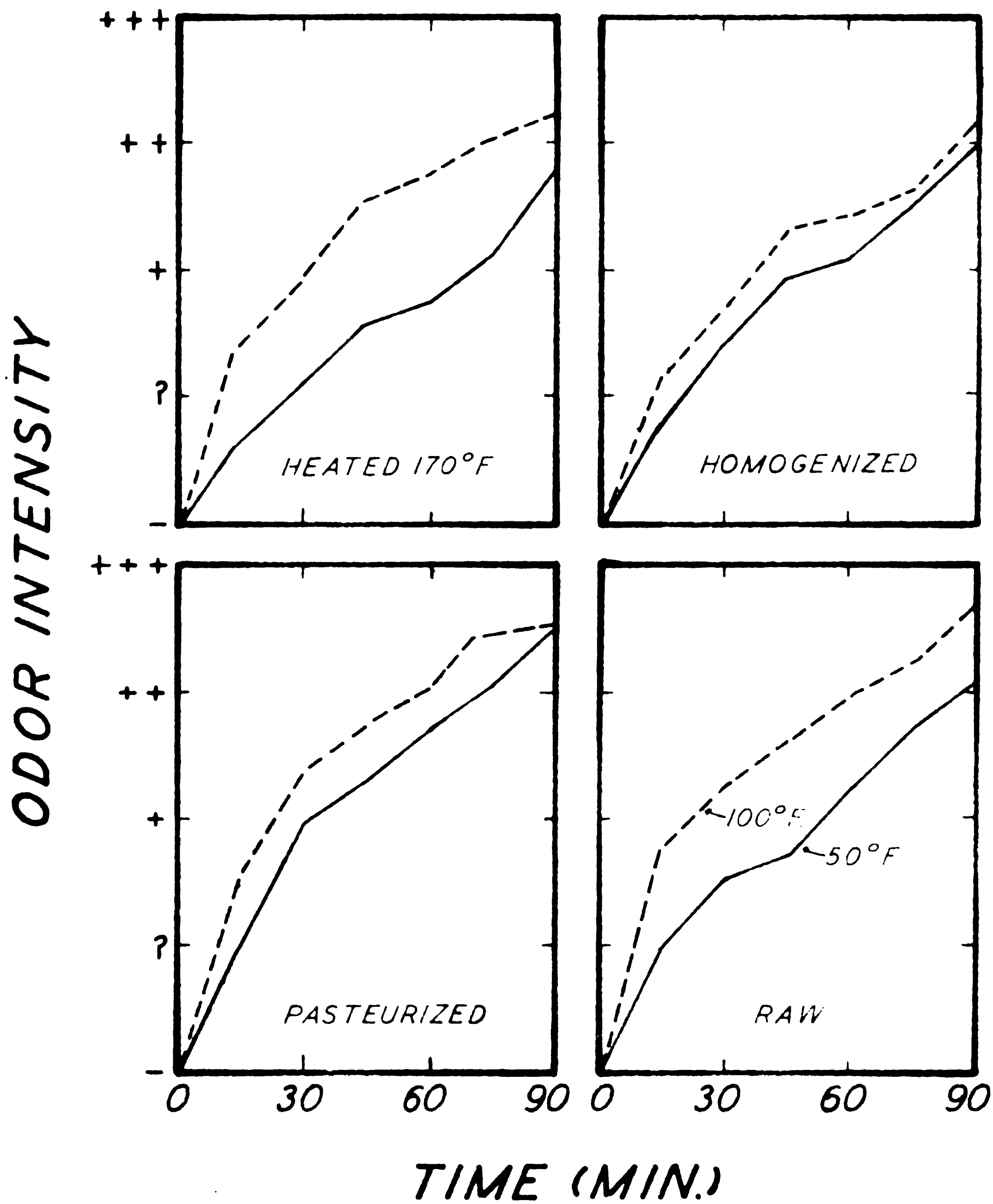

Figure 1. Intensity of absorbed odors when heated, homogenized, pasteurized and raw milk were exposed to odoriferous substances at 50° F. and at 100° F.

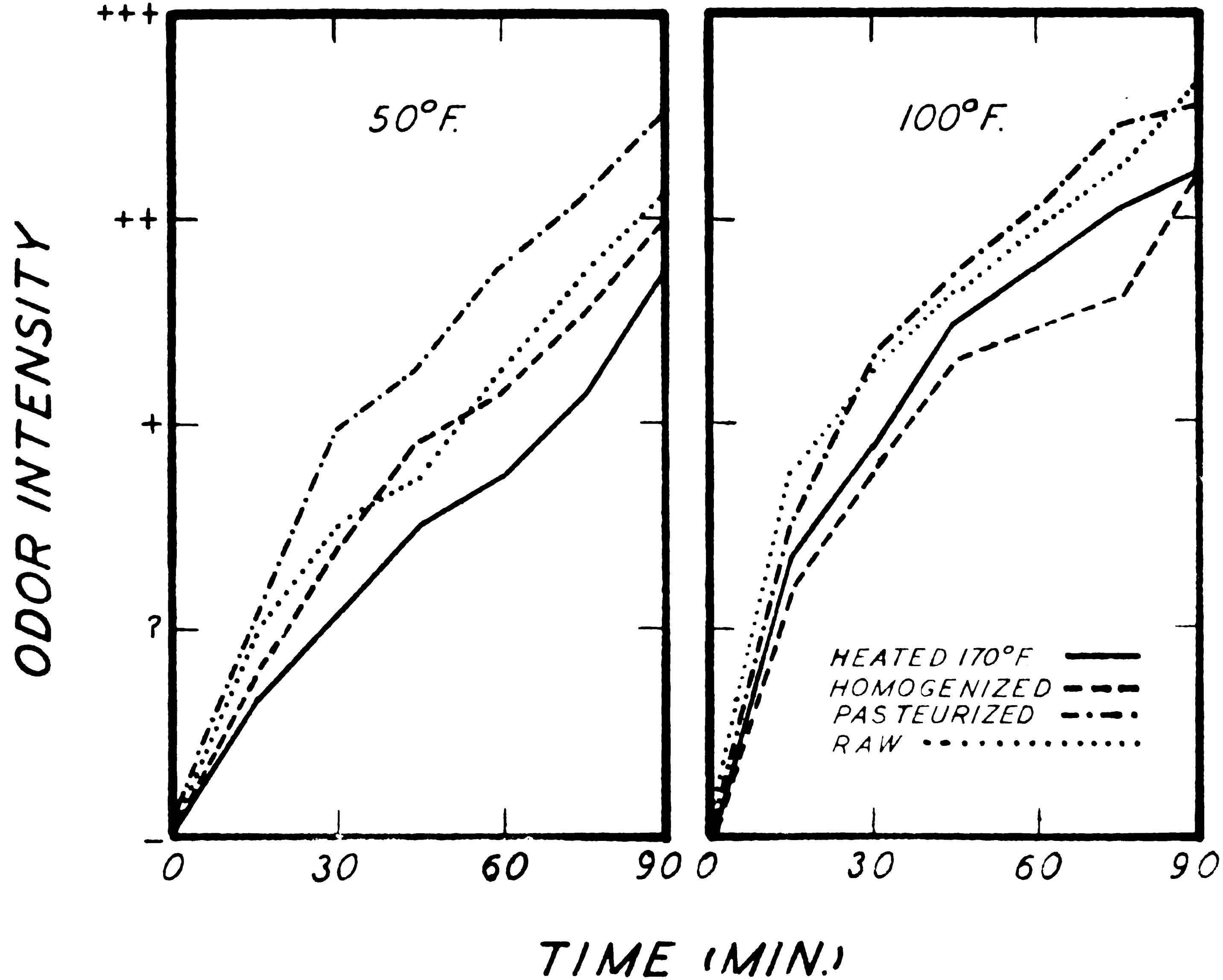

Figure 2. Intensity of absorbed odors when heated, homogenized, pasteurized and raw milk were exposed to odoriferous substances at 50° F. and at 100° F.

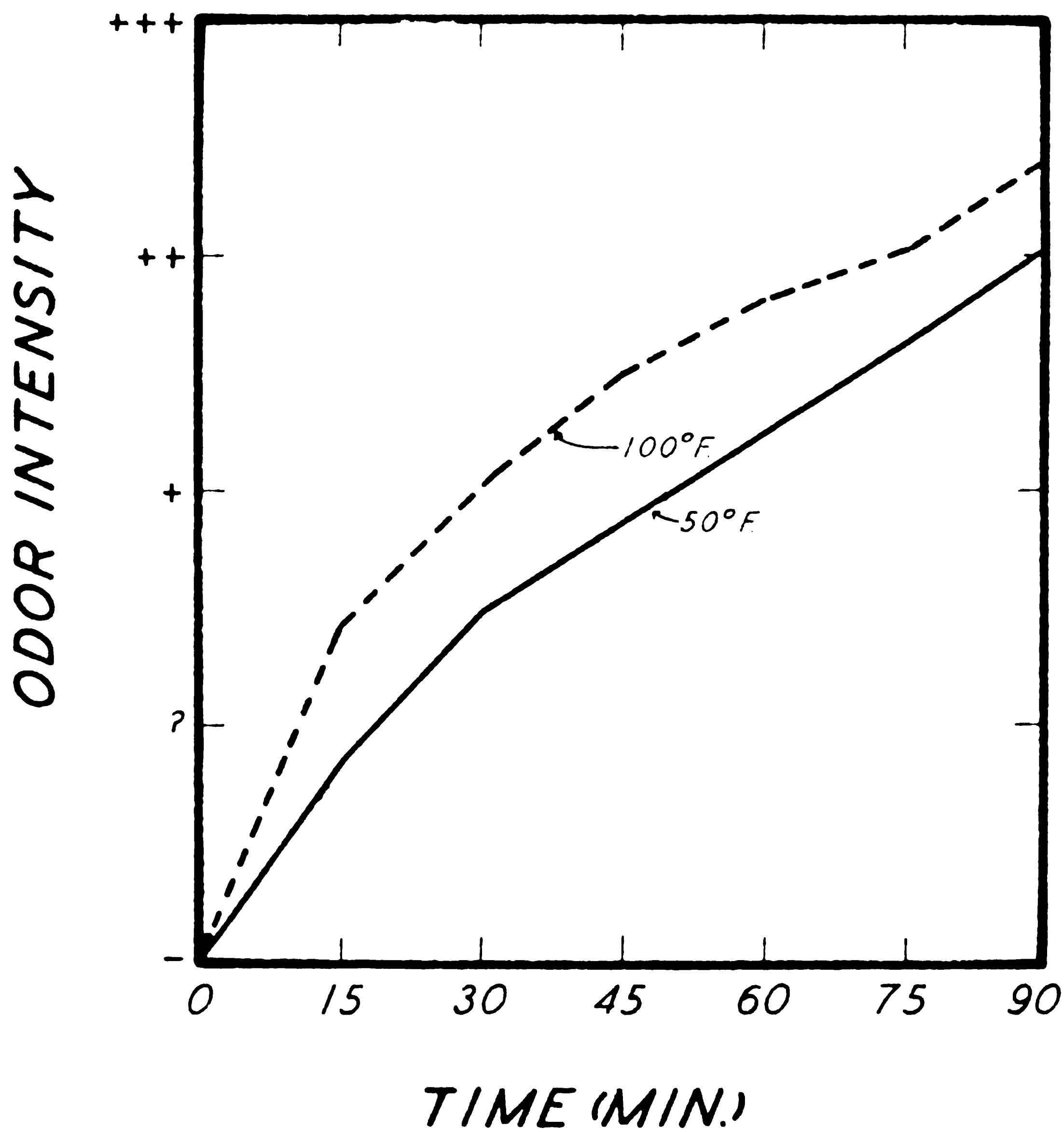

Figure 3. Intensity of odors absorbed by milk at 50° F. and at 100° F.

The relative absorption of odors by milk subjected to saturated atmospheres of various foods

Fifty ml. of heated, homogenized, pasteurized, and raw milk were exposed at 50° F. and at 70° F. to saturated atmospheres of various foods for a period of 1 and 24 hours. The samples were examined for identification of the odoriferous substance and for odor intensity after one hour and after 24 hours exposure. The data are summarized in tables 5, 6, 7, and 8.

From the results secured in this experiment it would indicate as previously shown in table 1 that milk with the fat in a liquid state would absorb more of the odoriferous substance than when the fat was in a solid state. Some discrepancies in the absorption of the foods were noted at the one hour exposure.

1. Absorption of odors by milk subjected to various foods at 50° F.

Samples of the different milks were exposed to the following raw sliced foods: bacon, banana, cabbage, onion, orange, potatoes, and turnips. In addition the milk was exposed to cooked cabbage and turnips and to washed and unwashed potatoes.

When heated, homogenized, pasteurized, or raw milk was exposed to the odor of bacon at 50° F. for one hour this odor could not be identified in the milk. Banana odor was recognized in heated and pasteurized milk but not in homogenized or raw milk. When the four different types of milk were exposed to cooked cabbage the odor was recognized while the odor of raw cabbage could not be identified. The onion and orange odors were recognized in heated, pasteurized, and raw milk but not in the homogenized

milk. When cut, unwashed, and washed potatoes were exposed to the different milks the potato odor could not be identified. The odor of cooked turnips was easily recognized in each different type of milk (Table 5).

When the different types of milk were exposed to bacon for 24 hours at 50° F. the odor was recognized in only one trial. When heated, homogenized, pasteurized, and raw milk were exposed for 24 hours to the odor of banana, onion, orange, and cooked turnips these odors were identified in the milk. Cooked cabbage was recognized in all the different milks. However, the raw cabbage was slightly fermented in one trial and caused an off-odor in the milk which could not be identified as cabbage. The potato odor could not be recognized when milk was exposed to cut, unwashed, or washed potatoes for 24 hours (Table 5).

Of the different foods exposed to heated, homogenized, pasteurized, and raw milk for one hour at 50° F. cooked cabbage was absorbed in the greatest intensity followed by cooked turnips. Heated, pasteurized, and raw milk absorbed medium quantities of the odor from onions and oranges. However, homogenized milk failed to absorb these two odors. Heated and pasteurized milk absorbed slight banana odors while homogenized and raw milk was negative to them. The different milks failed to absorb a detectable quantity of bacon, raw cabbage or potato odors (Table 6).

When the different milks were exposed for 24 hours at 50° F. the absorbed odors increased in intensity over the one hour exposure. This was especially noted in the homogenized milk. Cooked cabbage and turnips were absorbed in greatest intensity followed closely by onion, orange, and banana. Milks absorbed the bacon odor only slightly. The different milks again failed to absorb the odors from raw cabbage and potatoes (Table 6).

Table 5. Identification of odors in milk after an exposure of 1 and 24 hours to various foods at 50° F.

Odoriferous substance	No. of trials	Identification of odor after exposure of 1 hour at 50° F.				24 Hours at 50° F.			
		Heated	Homo.	Past.	Raw	Heated	Homo.	Past.	Raw
Bacon	2	-	-	-	-	*	*	*	*
Banana	2	+	-	+	-	+	+	+	+
Cabbage									
cooked	4	+	+	+	+	+	+	+	+
raw	2	-	-	-	-	**	**	**	**
Onion	2	+	-	+	+	+	+	+	+
Orange	2	+	-	+	+	+	+	+	+
Potatoes									
cut	2	-	-	-	-	-	-	-	-
unwashed	2	-	-	-	-	-	-	-	-
washed	2	-	-	-	-	-	-	-	-
Turnips									
cooked	4	+	+	+	+	+	+	+	+

Key:
- \- odor not recognized
- \+ odor recognized
- * bacon odor recognized in only one trial
- ** identified as off-flavor in one trial, cabbage fermented

Table 6. Intensity of odors in milk after an exposure of 1 and 24 hours to various foods at 50° F.

Odoriferous substance	No. of trials	Intensity of odor after exposure of 1 hour at 50° F.				24 hours at 50° F.			
		Heated	Homo.	Past.	Raw	Heated	Homo.	Past.	Raw
Bacon	2	-	-	-	-	?	+	?	?
Banana	2	+	-	+	-	++	+?	++	+?
Cabbage									
cooked	4	++	+?	+++	++	+++	++?	+++	+++
raw	2	-	-	-	-	-	-	-	-
Onion	2	++?	-	+?	+	+++	++?	+++	++
Orange	2	++	-	+?	+	+++	++	+++	++
Potatoes									
cut	2	-	-	-	-	-	-	-	-
unwashed	2	-	-	-	-	-	-	-	-
washed	2	-	-	-	-	-	-	-	-
Turnips									
cooked	4	++	+	++?	++	+++	++?	+++	+++

Key:
- \- no odor
- ? doubtful
- \+ slight odor
- ++ pronounced odor
- +++ very pronounced odor

2. Absorption of odors by milk subjected to various foods at 70° F.

The absorption of odors at 70° F. was increased over those at 50° F. When milks were exposed for one hour at 70° F. the odor of bacon, raw cabbage, and potatoes could not be distinguished. In heated and pasteurized milk the odor of banana, onion, and orange could be recognized while in homogenized milk these odors could not be distinguished. In raw milk the odor of onion was recognized in both trials while banana and orange could only be recognized in one trial. The odor of cooked cabbage and turnips was readily identified in the different types of milks (Table 7).

When the milks were exposed for 24 hours at 70° F. to various foods raw cabbage and potato odors could not be identified in them. The heated, homogenized, and pasteurized milk absorbed the odor of bacon but this odor could not be recognized in the raw milk. The odor of banana, cooked cabbage, onion, orange, and cooked turnips could be recognized in heated, homogenized, pasteurized, and raw milk (Table 7).

After exposure of milks for one hour at 70° F. thegreatest odor intensity was absorbed from cooked cabbage and turnips followed closely by onion, orange, and banana. The bacon and potato odors were not absorbed in detectable quantities by the different milks (Table 8).

When heated, homogenized, pasteurized, and raw milk were exposed for 24 hours at 70° F. to these same foods, cooked cabbage and turnips, banana, onion, and orange odors produced a very pronounced odor in the milk. The heated, homogenized, and pasteurized milk absorbed the bacon odor slightly while raw milk failed to absorb this odor. The milks did not absorb the odor of raw cabbage or potatoes at this exposure (Table 8).

Table 7. Identification of odors in milk after an exposure of 1 and 24 hours to various foods at 70° F.

Odoriferous substance	No. of trials	Identification of odor after exposure of 1 hour at 70° F.				24 hours at 70° F.			
		Heated	Homo.	Past.	Raw	Heated	Homo.	Past.	Raw
Bacon	2	-	-	-	-	+	+	+	-
Banana	2	+	-	+	*	+	+	+	+
Cabbage									
cooked	4	+	+	+	+	+	+	+	+
raw	2	-	-	-	-	-	-	-	-
Onion	2	+	-	+	+	+	+	+	+
Orange	2	+	-	+	*	+	+	+	+
Potatoes									
cut	2	-	-	-	-	-	-	-	-
unwashed	2	-	-	-	-	-	-	-	-
washed	2	-	-	-	-	-	-	-	-
Turnips									
cooked	4	+	+	+	+	+	+	+	+

Key: - odor not recognized
+ odor recognized
* odor recognized in only one trial

Table 8. Intensity of odors in milk after an exposure of 1 and 24 hours to various foods at 70° F.

Odoriferous substance	No. of trials	Intensity of odor after exposure of 1 hour at 70° F.				24 hours at 70° F.			
		Heated	Homo.	Past.	Raw	Heated	Homo.	Past.	Raw
Bacon	2	-	-	-	-	+	++	+	-
Banana	2	++	-	+	?	+++	+++	+++	+++
Cabbage									
cooked	4	++	+	++	++	+++	++	+++	+++
raw	2	-	-	-	-	-	-	-	-
Onion	2	++?	-	+	+?	+++	+++	+++	+++
Orange	2	++	-	+	?	+++	+++	+++	+++
Potatoes									
cut	2	-	-	-	-	-	-	-	-
unwashed	2	-	-	-	-	-	-	-	-
washed	2	-	-	-	-	-	-	-	-
Turnips									
cooked	4	++	+	++	++	+++	++	+++	+++

Key: - no odor
? doubtful
\+ slight odor
++ pronounced odor
+++ very pronounced odor

Absorption of odors by freshly drawn milk when exposed to various surroundings

Freshly drawn milk, having no abnormal odor, was divided into 12 lots which were exposed immediately to various atmospheres for a period of one and one-half hours. The atmospheres were those of the calf pen, milk room of the Dairy Barn, corn silo, gutter which contained manure, feed room, feed alley, barn ventilator exit, silo alleyway, bull pen, shavings bin, stall adjacent to a rumen fistula cow, and grass silo without a roof. The data obtained are shown in table 9.

An examination of the data obtained shows that an off-odor was obtained only when the warm milk was placed in the corn and grass silos and in the gutter. As trial 1 was run on a rather cool day, thus hastening cooling of the exposed sample, this would probably account for the decrease in odor intensity as compared to trials 2 and 3 which were carried out on rather warm days. The intensity of grass silage was the same in the three trials. However, in trial 1 grass silage fell into the six-inch culture dish which may account for the very pronounced odor in the milk on the rather cool day. In trials 2 and 3 straw fell into the dishes exposed in the gutter. This may account for the very pronounced manure odor as compared to trial 1. These results tend to disprove the old theory that milk exhaled odors when warmer and absorbed odors when colder than the atmosphere.

Table 9. Absorption of odors by freshly drawn milk exposed one and one-half hours to various surroundings.

Location of exposure	Prevailing odor	Intensity of off-odor noted in Trial 1	Trial 2	Trial 3
Calf pen	ammonia	-	-	-
Milk room	none	-	-	-
Silo (corn)	sharp pene trating silage	++	+++	+++
Gutter (manure in)	ammonia and manure	-	+++*	+++*
Feed room	none	-	-	-
Feed alley	cowy	-	-	-
Ventilator (exit)	none	-	-	-
Silo alleyway	faint silage	-	-	-
Bull pen	feed	-	-	-
Shavings (bin)	pine and turpentine	-	-	-
Stall adjacent to rumen fistula cow	putrid	-	-	-
Silo (grass) ventilated	strong penetrating butyric acid	+++**	+++	+++

Key:
- \- no odor
- ++ pronounced odor
- +++ very pronounced odor
- * straw fell into the dish and the sample smelt very strong of manure
- ** silage fell into the milk

Relative absorption of odors by warm milk placed in a silo for various periods of time

Samples of freshly drawn milk were exposed to the atmospheres in the corn and grass silos from 15 to 90 minutes and examined for odor intensity. The data obtained are presented in table 10 and figure 4.

The data showed that the odor of corn silage was absorbed in greater intensity than that of grass silage. When the warm milk was exposed on a cool day (March 27th) the odor absorbed was not as intense as when exposed on warm days (May 6th and May 8th). Pronounced odors were obtained in corn silage at the end of 30 minutes while in grass silage from 60 to 75 minutes of exposure were required. This was thought to be due to the fact that the corn silo was nearly empty and contained a very pronounced silage odor while the grass silage had been exposed to the weather and was quite dried out.

In the experiment of exposing heated, homogenized, pasteurized, and raw milk to saturated atmospheres of corn and grass silage in a desiccator, the grass silage odor was absorbed slightly more intensly than that of corn silage. This was especially noted at exposures under 45 minutes at 100° F. The fact that the grass silage odor was more intensely absorbed in this experiment as compared to the trials in which the milk was exposed in the silo was probably due to the fact that the silage was much more moist in the desiccator than it was in the silo.

Table 10. The relative absorption of odors by warm milk subjected to different types of silage when exposed for various periods of time.

Odoriferous substance	Date	Exposure (min.) at						
		0	15	30	45	60	75	90
Corn silage	3/27/41	-	-	1	1	1	3	3
	5/6/41	-	2	3	3	4	4	4
	5/8/41	-	2	3	3	4	4	4
	avg.	0	1.34	2.34	2.34	3.0	3.67	3.67
Grass silage	3/27/41	-	-	-	2	2	2	1
	5/6/41	-	-	2	2	3	3	4
	5/8/41	-	-	1	1	2	3	4
	avg.	0	0	1.0	1.67	2.34	2.67	3.0

Key:
- \- no odor
- 1 doubtful
- 2 slight odor
- 3 pronounced odor
- 4 very pronounced odor

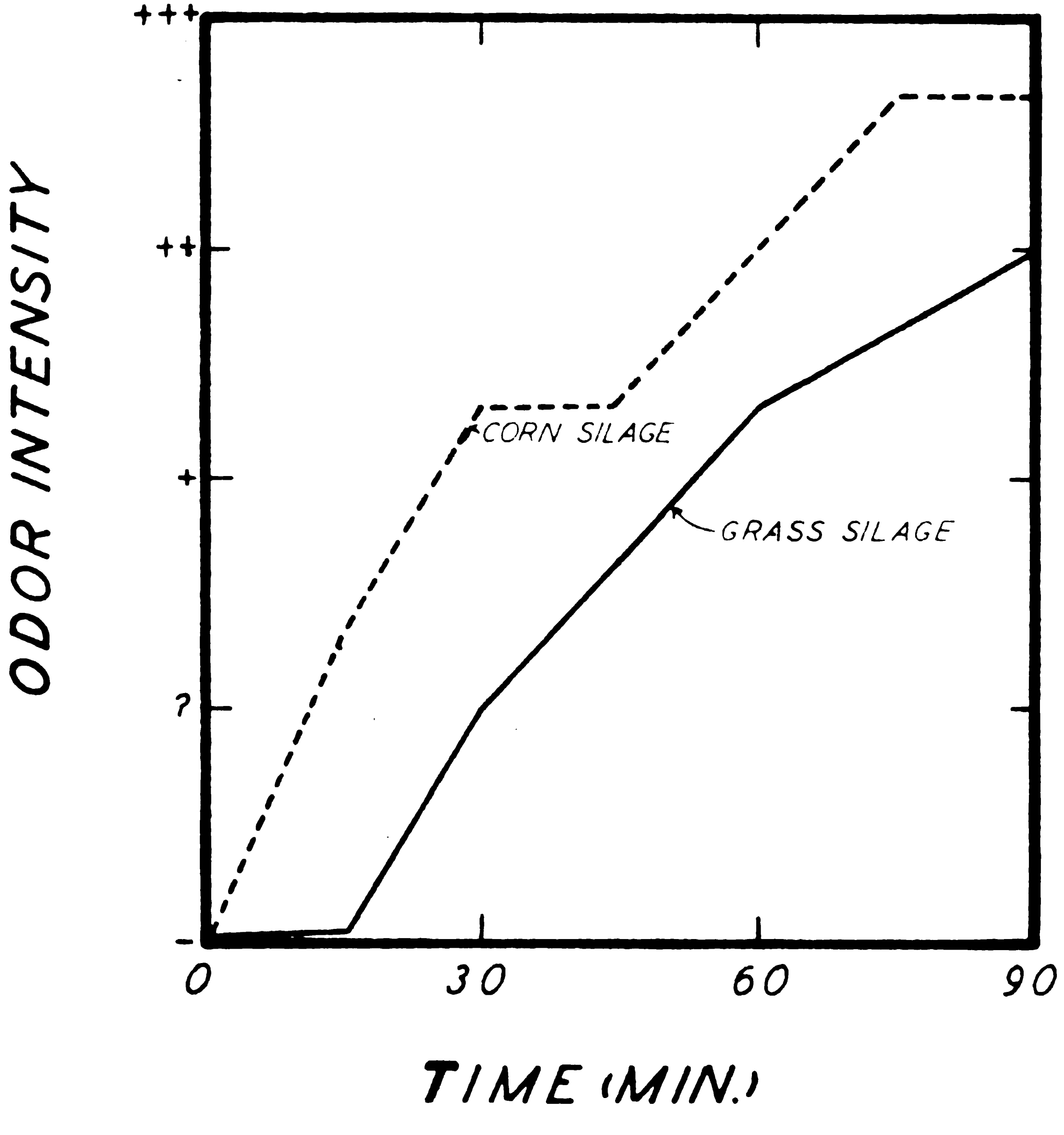

Figure 4. Intensity of corn and grass silage odors in milk when fresh warm milk was exposed to the silo atmosphere for one and one-half hours.

Penetration of odors in bulk pasteurized milk exposed to saturated atmospheres

Eighty pounds of pasteurized milk in a specially fitted ten-gallon milk can was exposed for one hour to grass silage and to turpentine. These two substances were wrapped or soaked in a cheese cloth which was placed on the under side of the can cover. After exposure this milk was drawn from the bottom of the can in ten separate eight-pound lots each of which was examined carefully for the odor to which the milk was exposed. The data obtained appears in tables 11 and 12.

An examination of the data in table 11 shows that when the milk was exposed to grass silage at 53° F. only the top eight-pound layer absorbed this substance. When this experiment was repeated with the milk fat in a liquid state (94° F.), this odoriferous substance was absorbed in the first and second eight-pound layers.

The data in table 12 show that relatively the same results were obtained for the turpentine as was found for silage. When pasteurized milk was exposed to the odor of oil of turpentine, only the top eight-pound layer at the 56° F. and the 95° F. exposures absorbed this odoriferous substance. These data indicated that turpentine was not absorbed to the same depth as was the odor of grass silage.

This experiment tends to show that the absorption of odors by milk takes place at the liquid surface and does not penetrate very far down in the liquid.

Table 11. Absorption of grass silage odor in various layers of 80 pounds of pasteurized milk during one hour exposure when odoriferous substance was suspended above the milk under the cover.

Respective 10 per cent layer of milk from top of can	Intensity* of grass silage odor when milk was exposed at	
	53° F.	94° F.
1st	+++	+++
2nd	-	++
3rd	-	-
4th	-	-
5th	-	-
6th	-	-
7th	-	-
8th	-	-
9th	-	-
10th	-	-

* average of opinions of 2 judges

Table 12. Absorption of turpentine odor in various layers of 80 pounds of pasteurized milk during one hour exposure when the odoriferous substance was suspended above the milk under the cover.

Respective 10 per cent layers of milk from top of can	Intensity* of turpentine odor when milk was exposed at 56° F.	95° F.
1st	+++	+++
2nd	-	-
3rd	-	-
4th	-	-
5th	-	-
6th	-	-
7th	-	-
8th	-	-
9th	-	-
10th	-	-

* average of opinions of 2 to 6 judges.

Rate of passage of various substances into milk when fed to the cow

Holstein cows No. 274 and 287 producing no abnormal milk were selected for this experiment. The odoriferous substances were placed in gelatin capsules and were forced into the rumen by a capsule gun. Samples of milk were obtained before the start of the experiment and at one-quarter, one-half, 1, 8, 16, 24, 32, 40, and 48 hours thereafter. The data secured are shown in tables 13, 14, 15, 16, and 17.

An examination of the data in these tables shows that certain types of odoriferous substances are absorbed more rapidly by milk inside the cow's body than others. For example, ethyl ether passes readily into milk while kerosene requires several hours.

1. Rate of passage of kerosene into milk

Gelatin capsules containing a total of 125 ml. of kerosene were forced into the rumen of cow No. 274. Trials were run to determine the time required by the capsules containing approximately 18 ml. of kerosene to dissolve completely in a pail of warm water at 102° F. and thus release the kerosene. The capsules were weighted so that they would be completely submerged in the warm water. Three trials were run and it was found that it required from 12 to 14 minutes to release completely the 18 ml. of kerosene.

No odor of kerosene was noticed on the cow's breath at the end of the one-quarter, one-half or one hour period. When the cow urinated at one and one-quarter hours after the start of the experiment, no odor of kerosene could be distinguished.

The data in table 13 shows that it required 8 hours after giving the cow kerosene before a slight odor was produced in the milk. The 16 hour sample showed the greatest odor intensity while at the 24 hour period the odor in the milk was greatly decreased. There was no increase or decrease in odor intensity when the cold milk was warmed to 102° F. and again graded.

From this experiment it can readily be seen that kerosene is not rapidly absorbed by milk inside the body of the cow, but yet it is very objectionable from the standpoint of off odor at certain periods after ingestion.

Table 13. Rate of passage of 125 ml. of kerosene into milk when fed to the cow (Avg. two trials)

Time of sampling	Intensity of odor and taste of kerosene in milk after various periods of ingestion when examined at 50° F.		102° F.	
	Odor	Taste	Odor	Taste
Control, before giving cow kerosene	-	-	-	-
¼ hour after giving cow kerosene	-	-	-	-
½ hour after giving cow kerosene	-	-	-	-
1 hour after giving cow kerosene	-	-	-	-
8 hours after giving cow kerosene	?	?	?	?
16 hours after giving cow kerosene	++	++	++	++
24 hours after giving cow kerosene	?	?	?	?
32 hours after giving cow kerosene	-	-	-	-
40 hours after giving cow kerosene	-	-	-	-
48 hours after giving cow kerosene	-	-	-	-

Key:
- \- no odor or taste
- ? slight odor or taste
- ++ pronounced odor or taste

2. Rate of passage of ethyl ether into milk

Thirty ml. of ethyl ether was placed in two gelatin capsules and given to cow No. 287. Trials were run to find out the time required to dissolve the gelatin capsules containing 15 ml. of ethyl ether in water at 102° F. Four trials were run and the results indicated that it required from 5 1/3 to 6½ minutes to release completely the ethyl ether.

This odoriferous substance was quickly noticed on the breath of the cow. At the one-quarter, one-half, and one hour milkings the cow's breath contained a very pronounced ethyl odor. No odor was noticed in the urine at one and one-half hours after the start of the experiment.

From the data in table 14 it will be seen that the odor of ethyl ether was pronounced in the milk obtained at the one-quarter hour milking. At the one-half and one hour milkings a very pronounced odor was obtained. When the cold milk samples were warmed to 102° F. the odor intensity decreased slightly. This might have been due to the fact that the ethyl ether evaporated more readily at high temperatures.

Table 14. Rate of passage of 30 ml. of ethyl ether into milk when fed to the cow (Avg. two trials)

Time of sampling	Intensity of odor and taste of ethyl ether in milk after various periods of ingestion when examined at			
	50° F.		102° F.	
	Odor	Taste	Odor	Taste
Control, before giving cow ethyl ether	-	-	-	-
¼ hour after giving cow ethyl ether	++	++	++	+++
½ hour after giving cow ethyl ether	+++	+++	++	+++
1 hour after giving cow ethyl ether	+++	+++	++	+++
8 hours after giving cow ethyl ether	-	-	-	-
16 hours after giving cow ethyl ether	-	-	-	-
24 hours after giving cow ethyl ether	-	-	-	-
32 hours after giving cow ethyl ether	-	-	-	-
40 hours after giving cow ethyl ether	-	-	-	-
48 hours after giving cow ethyl ether				

Key: - no odor or taste
++ pronounced odor or taste
+++ very pronounced odor or taste

3. Rate of passage of onion into milk

Thirteen gelatin capsules containing 304 grams of finely chopped up onion greens were forced into the rumen of cow No. 287. As some of the juice from the onion greens necessarily got on the outside of the gelatin capsules during filling, thus yielding an onion odor they were rinsed in 95 per cent alcohol prior to administration to eliminate any odor of onion.

No odor of onion was noted on the cow's breath at the one-quarter, one-half, and one hour milkings. When the cow urinated one-quarter of an hour after the start of the experiment no odor of onion was noted.

The data in table 15 shows that onion produced a pronounced odor and taste in the milk at the end of the one-hour ingestion period. At the 8 hour period the odor and taste decreased somewhat. When the cold samples were warmed to 102° F. and again graded there was no noted change in the odor and taste intensities.

Table 15. Rate of passage of 304 grams of onions into milk when fed to the cow.

Time of sampling	Intensity of odor and taste of onions in milk after various periods of ingestion when examined at			
	50° F.		102° F.	
	Odor	Taste	Odor	Taste
Control, before giving cow onion	-	-	-	-
¼ hour after giving cow onion	-	-	-	-
½ hour after giving cow onion	-	-	-	-
1 hour after giving cow onion	++	++	++	++
8 hours after giving cow onion	+	+	+	+
16 hours after giving cow onion	-	-	-	-
24 hours after giving cow onion	-	-	-	-
32 hours after giving cow onion	-	-	-	-
40 hours after giving cow onion	-	-	-	-
48 hours after giving cow onion	-	-	-	-

Key: - no odor or taste
+ slight odor or taste
++ pronounced odor or taste

4. Rate of passage of Sudan III dye to milk after ingestion

For this experiment a high producing cow and a low producing cow were used. Both these cows were on three times a day milking. Cow No. 274 produced on an average 22 pounds of milk per milking. To this cow 30 ml. of Sudan III dye was administered. Cow No. 287 produced on an average 12 pounds of milk per milking. To this cow 15 ml. of dye was administered.

From 11 to 13½ minutes were required for the dye to be released completely from the gelatin capsule. When the cows urinated at one and one-half hours no red color was noted.

Upon examination of the data presented in table 16 it will be seen that the Sudan III dye showed up in the butter after 8 hours following ingestion. At this period the butter from cow No. 274 contained a pronounced reddish color while the butter obtained from cow No. 287 contained only a slight reddish color. At the 16 hour ingestion period a very pronounced reddish color was noted. At the 24, 32, 40, and 48 hour ingestion periods a pronounced reddish color was noted in the butter churned from the milk of cow No. 287. When the larger quantity of dye was administered to cow No. 274 giving the greater amount of milk, the butter obtained at the above respective periods, with the exception of the 48-hour period, was very pronounced red.

Table 16. Rate of passage of Sudan III into milk fat.

Time of sampling	Intensity of color in butter churned from milk when	
	15 gms. dye was given to cow No. 287	30 gms. to cow No. 274
Control, before giving cow dye	-	-
¼ hour after giving cow dye	-	-
½ hour after giving cow dye	-	-
1 hour after giving cow dye	-	-
8 hours after giving cow dye	?	+ +
16 hours after giving cow dye	+ + +	+ + +
24 hours after giving cow dye	+ +	+ + +
32 hours after giving cow dye	+ +	+ + +
40 hours after giving cow dye	+ +	+ + +
48 hours after giving cow dye	+ +	+ +

Key:
- \- no color
- ? slight color
- \+ + pronounced color
- \+ + + very pronounced color

5. Rate of passage of formaldehyde into milk

Samples of milk were obtained from two cows before the commencement of the experiment and at 8 and 16 hours after ingestion of 25 ml. of formaldehyde. The purple ring test for formaldehyde was run and the odor and taste noted. The results secured appear in table 17.

The results from table 17 show conclusively that no odor or taste of formaldehyde could be noted in the samples of milk. Negative results were noted when the samples of milk were submitted to the purple ring test for formaldehyde.

Table 17. Rate of passage of 25 ml. of formaldehyde into milk when fed to the cow.

Time of sampling	Cow No.	Intensity of odor and taste of formaldehyde when examined at 50° F. Odor	50° F. Taste	102° F. Odor	102° F. Taste
Control, before experiment	A23	-	-	-	-
8 hours after giving cow formaldehyde	A23	-	-	-	-
16 hours after giving cow formaldehyde	A23	-	-	-	-
Control, before experiment	D 5	-	-	-	-
8 hours after giving cow formaldehyde	D 5	-	-	-	-
16 hours after giving cow formaldehyde	D 5	-	-	-	-

DISCUSSION

Samples of heated, homogenized, pasteurized, and raw milk were exposed at 50° F. and at 100° F. to saturated atmospheres of various odoriferous substances from 15 to 90 minutes and examined immediately after the experiment and after 24 hours. The results secured indicated that the different milks varied somewhat in their absorptive capacity to take up the odoriferous substance.

The milk with the fat in a liquid state absorbed the odoriferous substance faster as well as in greater quantities than when the fat was in a solid state. This was also found to be true when the different types of milk were exposed to various foods for 1 and 24 hours at 50° F. and at 70° F. However, the odor of all foods were not readily absorbed by the milk. Even after 24 hours the odor of some foods, bacon for example, only slightly tainted the milk.

Absorption of odors appeared to be largely a surface problem. Eighty pound lots of pasteurized milkin a specially fitted ten-gallon milk can were exposed for one hour to the odor of grass silage and turpentine by suspending these odoriferous substances under the cover above the milk. Milk was drawn from the bottom of the can in ten separate eight-pound lots. The results showed definitely that only the upper layers absorbed the odoriferous substance.

In comparing the absorption of odors in saturated and unsaturated atmospheres, it was noted that saturated atmospheres generally produced pronounced odors in the milk after 30 minutes exposure to the odoriferous substance. On the other hand, when the samples were exposed to unsaturated atmospheres the odors in the milk, if detectable, were not so pronounced at the same period of exposure.

Even when milk was exposed to various surroundings in the stable only the odor of manure was obtained in the milk at the end of one and one-half hours exposure and then only when straw containing manure fell into the milk. When milk was exposed in saturated atmospheres in a desiccator containing fresh and liquid manure and fresh urine, pronounced odors were noted in the 15 minute exposure when the milk was at 100° F. It would appear, therefore, that the possibility of absorption of odors by milk after being drawn and before removal from the stable was much over emphasized.

Naturally as the time and temperature of the milk were increased, the absorbed odor was greatly increased.

The rate of passage of an odoriferous substance into milk through the body of the cow would seem to depend upon several factors such as the nature of the odoriferous substance, the readibility by which the substance passes through the rumen wall, and its contact with the respiratory system through several channels.

Various different types of odoriferous substances were sealed in gelatin capsules so as to eliminate odors about the mouth and forced into the rumen of the cow. When 125 ml. of kerosene were administered to the cow, it required 8 hours before a slight odor could be noted in the milk. On the other hand, using only 30 ml. of ethyl ether, a pronounced odor was produced inthe milk at the end of one-quarter of an hour. Likewise, 304 grams of capsuled chopped onion tops produced an off-odor in one hour.

When a substance such as Sudan III, which contained no odor, was administered to the cow, the fat of the milk was colored in 8 hours. Thus it appears that odoriferous substances affecting milk within a short period, within one hour, must gain entrance to the blood stream either through the respiratory tract or through penetration of the rumen wall. Otherwise, the odor of the milk may not be affected until after sufficient time for the odoriferous substance to enter or pass through the normal digestive processes of the cow.

SUMMARY

Samples of heated, homogenized, pasteurized, and raw milk were exposed to odoriferous substances at 50° F. and at 100° F. from 15 to 90 minutes. In general, it required 30 minutes or longer before pronounced odors were detectable in the milk. The milk having the fat in a liquid state absorbed the odoriferous substance faster as well as in greater quantities than that in which the fat was in a solid state. Under similar exposures pasteurized and raw milk, which exhibited creaming, usually absorbed more intense odors than did heated and homogenized milk, which exhibited no creaming.

The various milks, exposed in saturated atmospheres, absorbed pronounced odors of foods such as; cooked cabbage, cooked turnips, oranges, and onions at a 24 hour exposure. Banana odor was absorbed to a lesser extent, while bacon was only slightly absorbed. On the other hand, odors of raw cabbage, cut, unwashed, and washed potatoes were not detectable in the milk at similar exposures.

Samples of milk were exposed to the atmosphere in the corn and grass silos from 15 to 90 minutes. Under the conditions of the experiment, thirty minutes in the corn silo were required to produce a pronounced odor in the milk as contrasted to 60 to 75 minutes in the grass silo.

Absorption of odors by fresh warm milk exposed one and one-half hours in various atmospheres incident to the stable were negative except in cases where substances giving rise to the odor actually got into the milk.

The absorption of odors by milk took place at the surface and did not penetrate very far down into the liquid.

The rate of passage of various substances into milk when fed to the cow varied greatly. The odor of kerosene was noted in the milk 8 hours after administration of the sealed capsules; ethyl ether produced pronounced odors in 15 minutes; while onions, similarly administered, required one hour to produce a distinct odor and taste in the milk. When a dye such as Sudan III, which was odorless, was administered to the cow, it required 8 hours to color the fat of the milk.

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