

## Potential sources of defect milk flavour

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**Summary.** The paper provides a survey of the possibilities of the occurrence of different types of defect milk flavour. The author used information from the relevant literature as well as his own experience. Some potential sources of the defect milk flavour are schematically illustrated. The adverse effects on milk flavour have been emphasized — especially those influencing its aroma, such as the effect of lactation, health condition of dairy cows, feeding, pollutants, microbial contamination of milk, non-hygienic milking, storing, packing — separately the effect of light and thermal treatment of milk, etc.

Also the topical character of the problem of the defect milk flavour all over the world and in our country has been discussed, as well as the necessity of proper orientation of workers dealing with its solution under our conditions.

Defect flavour of milk has been rather extensively described in scientific — and particularly in foreign literature. As far as these problems are concerned there is an excellent study of a team of American authors — Shipe et. al. [33] providing a survey of the individual types of defect flavour, their nomenclature, with extensive references. The above mentioned problem is comprised also in other papers [2—4, 7, 8, 10, 19, 22, 26]. It results from the above mentioned that the problem of defect flavour of milk is of a world-wide character and always topical.

With regard to the outlasting seriousness of the problem, as well as in connection with the necessity of proper orientation of workers interested in the solution of these problems in our conditions it was found to be unavoidable to summarize the information and knowledge on defect flavour of milk known till now — especially with respect of stressing its individual potential sources.

## 1. Remarks on Characteristic Milk Flavour

It has been found that there are numerous, mostly volatile compounds with different functional groups participating in the formation of characteristic flavour of mil. For instance, their count in sterilized milk exceeds the value of 400 [2]. There is an exact equilibrium between these compounds. Its disturbance, or eventual addition of foreign substances result in defect flavour.

It has been proved that the metabolism of a dairy cow is able — under normal conditions — to produce majority of compounds responsible for the characteristic flavour of milk — in case of aroma-free synthetic diet the dairy cows produced milk with normal, characteristic flavour [19].

## 2. Sources of Defect Milk Flavour

A survey of the potential sources of the defect milk flavour is shown in Fig. 1. In the following chapters the individual cases will be discussed.

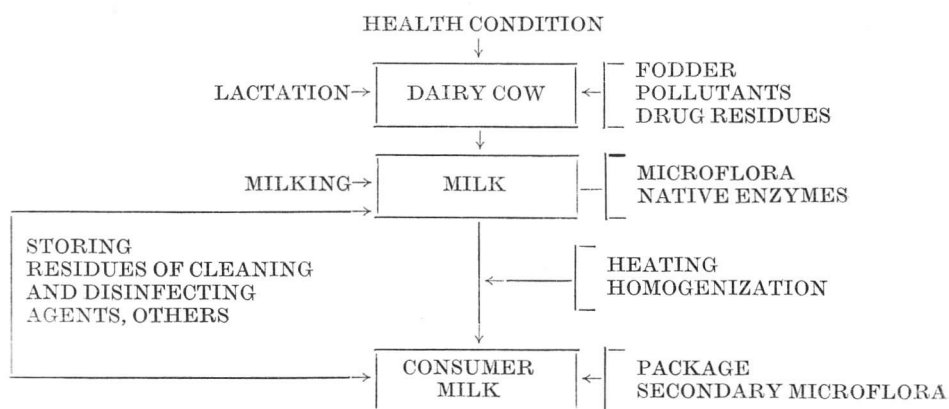


Fig. 1. Schematic illustration of some potential sources of defect milk flavour

### 2.1 Fodder

Defect milk flavour can appear already in the dairy cow mammary gland. It is caused by different types of fodders, eventually by smelling compounds from the environment. The critical compounds are transferred through the rumen or lungs into blood, and thus to the mammary gland.

The effect of fodder on the defect milk flavour has been known for a long time. For instance, in 1757 bitter flavour of milk from the dairy cows fed the leaves of turnips was observed. In 1829 the effect of dairy cow feeding with several species of turnips on the milk flavour was studied in England [30].

Till 1940 there were several hundreds of papers published especially by American farms and dealing with the reasons and methods how to avoid the defect milk flavour and defect flavour of the products from it [30].

Jennes and Patton [16] classified some types of fodders and weeds according to their effects on the milk flavour (Tab. 1).

Tab. 1. Effect of different fodders and weeds on defect milk flavour [16]

Source of flavour after fodder	Source of flavour after weeds	Fodders with little effect
onion, silage, alfalfa, cabbage, rape, turnip, beet tops, green barley, clover hay, distillers, grains, brewers grains, musty hay or silage	garlic, chives, mustard, buckhorn, ragweed, wild tansy, dog fennel	sugar beet, soy beans, carrots, pumpkins, soyabean hay, potatoes, oats, rye, peas, corn, legumes, clover, grass, timothy hay, tankage

Fodder can influence milk flavour also indirectly. It can contain some unstable compounds which are degraded by the dairy cow metabolism and provide compounds with adverse effects on milk flavour. For instance, a high amount of dimethylsulphide in milk can be due to the excessive feeding with alfalfa.

Some fodder components can also change the physiological status of the dairy cow which may result in changed milk flavour. For instance, feeding some Cruciferae can induce production of scatol and indol (from tryptophan) causing thus defect milk flavour [7].

## 2.2 Pollutants

Fresh milk is known with wide-spread, almost everywhere present defect milk flavour (of drugs, chemicals, etc.) caused by halogenated phenols, especially by chlorophenols. These can be formed from pesticide and disinfecting agent residues as well as from polluted air and water [37]. Chlorophenols are produced most frequently by the reactions between traces of e. g. hypochlorite from insufficiently washed milking machines, or sanitary reservoir residues, or udder, with phenol substances which are used by farmers as disinfecting agents or plant protection agents. It is of interest that chlorine or phenol can cause a drug flavour in milk only if their concentration exceeds 60 ppm. Chlorophenols, however, are more than 1000 times more efficient [7, 19].

Mesityloxide as a *pollutant of dyestuff solvent* causes defect milk flavor known as „catty flavour“ when in contact with milk. It is a reaction product of mesityloxide with carbon disulphide or SH-groups of milk proteins.

### 2.3 *Health Condition of Dairy Cows*

This fact can change milk flavour significantly. Disturbed equilibrium between the mineral substances and lactose of milk, for instance during mastitis, can cause salty taste. Ketosis of dairy cows results in production of milk with an increased level of acetone (50—100 ppm) giving the milk a flavour of cow or cow-shed. At a high concentration of acetone the milk flavour changes to a flavour of drugs or acetone.

In 1975 cow-shed flavour was detected in milk of some milk-collecting plants of Prievidza — but also in consumer milk. It was due to the increased acetone amount in milk because of ketosis of cows [24].

Here, one should mention also the possibilities of influencing the milk flavour by drugs. This occurs especially in the case of over-dosing of drugs and non-observance of the valid instructions on the waiting period when milk must not be processed for dairy purposes. For instance, the smell of tar, cigarette stubs, etc. appeared in the case of overdosing „Tetrafinol“ applied for preventive inoculation of dairy cows against the liver parasites. The active substance in this case was  $\text{CCl}_4$  [18, 24].

### 2.4 *Lactation*

At the end of lactation dairy cow's milk has a tendency to be more salty than at the beginning [10]. Late lactation increases sensitivity of milk to defect flavour in general, and especially rancid flavour caused by milk fat hydrolysis.

### 2.5 *Milking*

In this case the source of the defect flavour of milk consists particularly in its non-hygienic receiving when undesirable microflora gets into milk (e. g. coli aerogenes and psychotrophic bacteria).

Milk absorbs easily different odours, e. g. of cow-shed, paints. It can get also odour of rubber which is caused e. g. by rubber parts of the milking machine — it is caused by benzothiazole [19]. Also getting the odour from different agents applied to the udder, hands of the milker, etc. is quite frequent.

The tendency of milk to absorb odours is directly proportional to [11, 12]:

- milk fat contents
- concentration of volatile substances in air
- temperature of air (or pressure of volatile substance vapours)
- time interval during which milk is in contact with odours.

It has been found that milk absorbs odours 50—90 times more intensively

when mixed than in the case when its surface is calm. It results from the above mentioned that spattering of milk and foaming e. g. during milking increase the possibility of absorption of the cow-shed odours or of other odours from air.

## 2.6 Defect Milk Flavour of Microbial Origin

In practice there are many cases of the defect milk flavour caused by bacteria, yeasts or moulds. If milk is kept for a longer time in cold rooms, often bitter, fruit-like and also putrid, etc. flavour is observed. In such a case it is due to the activity of psychrotrophic microflora. It was found, for instance, that the fruity flavour is due to the presence of ethylesters of lower fatty acids (*Pseudomonas fragi*), and the unclean flavour can be due to the increased concentration of dimethylsulphide. Although the above mentioned cases concern mostly consumer milk, unclean and fruity flavours of milk are rather frequent also in mixed raw milk stored in cold rooms for a longer period of time.

Malt-like flavour of milk is caused by the presence of 3-methyl butanol and 2-methyl propanol produced by *S.lactis* var. *maltigenes*.

A survey of some types of defect milk flavour of microbial origin is shown in Tab. 2.

Also a close relationship between the occurrence of defect consumer milk flavour and increased total count of microorganisms in raw milk has been observed [37].

Tab. 2. A survey of some types of defect milk flavour of microbial origin [10, 21, 26]

Flavour	Compound	Microorganisms
Unclean	Dimethylsulphide	Psychrotrophic bacteria
Malt	2-methyl propanol	<i>Streptococcus lactis</i>
	3-methyl butanol	var. <i>maltigenes</i>
Fruity	Ethylesters of lower fatty acids	<i>Pseudomonas fragii</i>
Phenolic	Probably cresols	<i>Bacillus circulans</i>
Acidic	Lactic acid	Lactic streptococci
Rancid	Lower fatty acids	Lypolytic microbes (also other origin)
Potato musty	Pyrazines	<i>Pseudomonas taetrolens</i>

## 2.7 Presence of Native Enzymes in Raw Milk

When storing raw milk under the conditions that are favourable for the activity of the native enzymes, bitter, rancid, unclean, etc. flavours of milk can occur. These changes are caused most frequently by proteases or lipases.

## 2.8 Thermal Treatment of Milk

Milk for direct consumption is thermally treated at higher temperatures. When heating milk its original flavour changes. This change depends on the temperature and interval of the treatment, as well as on the quantity of burnt-in materials on the machine surface.

In the literature several terms for the defect milk flavour caused by heating are described. They are, for instance, heated, nutty, scalded, burnt, scorched, custard-like, rice pudding, caramel, etc. [10, 17]. All these types are frequently called „cooked“ flavour of milk.

More delicate changes in milk flavour caused by milder heating are due to the changes of proteins — especially those of whey and fat globule membranes. More significant changes in flavour (burnt, caramel) are due to protein degradation which also results in interactions with lactose and its degradation products (10).

Milk treated at high temperatures (e. g. 140 °C, 3—4 sec.) can have so called astringent flavour. Quite frequently also cabbage-like flavour can be found. This is caused by the presence of  $\text{H}_2\text{S}$ ,  $\text{CH}_3\text{—SH}$  and  $\text{CS}_2$  [17].

Dumont and Adda have described in their book entitled „Progress in Flavour Research“ [19] the mechanism of milk flavour formation by heating as follows:

1. During milk heating degradation or cyclization of thermolabile precursors of flavour and aromatic substances present in milk takes place. Thus, for instance,  $\beta$ -keto acids and  $\gamma$ - or  $\delta$ -hydroxyacids are converted into methyl ketones, and  $\gamma$ - or  $\delta$ -lactones, eventually from sulphonie salts of methylmethionine dimethylsulphide is formed.

2. During heating milk reactions between lactose and proteins take place — Maillard reactions. During these reactions aldehydes, acids and  $\alpha$ -diketones are formed, or by dehydration furan derivatives are produced. By the Strecker reaction between amino acids and newly formed  $\alpha$ -diketones aldehydes can be produced (e. g. phenylacetaldehyde).

3. During heating milk sulphur compounds are released. They include especially hydrogen monosulphide released mostly from activated sulphydryl groups of  $\beta$ -lactoglobulin. Methional dimethyl disulphide and methanethiol formed most probably from methionine are also present in heated milk.

Production of hydrogen monosulphide is considered to be one of the most significant features of changes in heated milk flavour. During storing such milk — e. g. UHT-sterilized milk — the quantity of hydrogen monosulphide decreases and thus also the cooked flavour is loosing.

The conditions of milk heating with respect to defect milk flavour were described in detail by Harper and Hall [10] and others [2, 13, 14, 16, 17].

Defect milk flavour can be caused by its steam treatment as well. In this case it is polluted steam incorporated to milk. Such milk can have uncertain flavour called e. g. a flavour of smoked ham [10].

Jarchová et al. [15] found flavour of milk, cream and butter, eventually of cheese which suggested burnt milk. It was caused by cleaning the boiler with „Ryfolgan“, urea and sodium sulphate. During steam generation these compounds caused burnt odour which contaminated the whole dairy plant.

## 2.9 *Milk Storing*

During storing milk can get defect flavour of different origin:

- bacteria (mostly streptococci, psychrotrophic bacteria)
- enzymes (native and bacteria enzymes)
- flavour caused by light effect (sunlight and oxidation flavour)
- flavour caused by spontaneous oxidation
- flavour caused by Maillard reactions

### 2.9.1 *Defect Milk Flavour of Bacterial Origin*

In this connection one should mention that deterioration of milk by bacteria of milk souring occurs now rather rarely as milk is first thermally treated and only then stored in cold rooms. Much more dangerous are psychrotrophic bacteria. Their lipolytic and proteolytic enzymes cause unclean, bitter or fruit-like flavour of milk. It was found that extended storing of milk before pasteurization has adverse effects on its quality keeping after pasteurization and thus, occurrence of bitter, unclean, putrid, fruit-like or yeast-like flavour is more probable. It was found that it is closely connected with the degree of milk protein hydrolysis which took place during previous longer storing of milk [40].

### 2.9.2 *Defect Flavour of Enzyme Origin*

This is ascribed to the activity of native lipase or protease. By hydrolysis of milk fat triacylglycerols „bad smelling“ free fatty acids are released. If such a change took place in raw milk so called „lipolytic musty smell“ is produced — a defect flavour which remains in milk even after its heat treatment. Tendency of milk to the above mentioned change in its flavour is increased by mechanical damaging of the fat globules.

In the case of the activity of native enzymes extensive occurrence of bitter milk flavour can be observed. Under normal conditions majority of native proteases are inactivated by pasteurization. Proteases are rather resistant to heating.

Lipases and proteases of microbial origin — especially those which are produced by the psychrotrophic bacteria of the *Pseudomonas* genus are rather thermoresistent. If they are present in high counts they remain even during UHT milk treatment. When storing UHT-sterilized milk at room temperature even low quantities of the active enzyme can cause changes in milk flavour. Rancid flavour of milk (lipase) can occur, or bitter flavour (protease).

### 2.9.3 *Defect Milk Flavour Caused by Light Effects*

This type of the defect milk flavour has been studied the best from among all types of the defect flavours. Information and knowledge on the light effect on milk flavour were summarized by e. g. Bradley [5], White and Bulthaus [38], Dimick [6] and others [9, 32, 34, 35, 39].

Light induces two types of defect flavour in milk: oxidation and sunlight.

#### 2.9.3.1 *Sunlight Flavour of Milk*

Its origin is connected with the degradation of a fraction of serum milk proteins. As its „originator“ a sulphur-containing compound is considered — methional ( $\beta$ -mercaptomethylpropionaldehyde) which is formed from methionine under the effects of light in the presence of riboflavin. It evokes a flavour of burnt protein, burnt feathers, fungi, putrid, disgusting, etc.

#### 2.9.3.2 *Oxidation Flavour of Milk*

It is termed as tallowy, oily, cardboard-like, fishy, of paint, etc. It is formed more slowly under the effect of light than the sunlight flavour. It is connected with photooxidation of the lipidic component of milk. This is formed by carbonyl compounds — oxidation degradation products of unsaturated fatty acids of milk fat. Also copper and more or less iron participate in its production in addition to light.

It is known in practice that the most of consumers easily find the sunlight milk flavour and become averse to it than to any other flavour defect.

The defect milk flavour caused by light can be avoided by its storing in dark and especially by using proper packages.

#### 2.9.4 *Oxidation Flavour of Milk*

This flavour is caused by spontaneous oxidation of milk fat without the effect of light. It is frequently described as cardboard-like. Its production is catalyzed by copper as well as by iron. The above mentioned type of flavour



can appear rather quickly in raw milk without evident reasons. In pasteurized milk stored in a dark and cold (7 °C) room oxidation changes in fat can take place with production of volatile secondary products. This results in unfresh flavour the intensity of which increases proportionally with the time of storing, and changes to the oxidation one [1].

It is stated that the character of spontaneously oxidized flavour differs from the light-induced oxidation milk flavour. This difference is caused by the fact that the spontaneous oxidation takes place rather on phospholipids than on triacylglycerols of milk fat. The defect flavour known as flavour „of paint“ is found more in milk after sunlight-unduced oxidation, and the cardboard-like flavour occurs in milk after spontaneous oxidation.

### 2.9.5 *Maillard Reactions*

These reactions take place in milk treated at higher temperatures during its long term storing at room temperature.

### 2.10 *Homogenization*

By milk homogenization the sensitivity of the serum proteins to their degradation increases. Thus, it results that homogenized milk is more sensitive to the occurrence of defect sunlight flavour than non-homogenized milk. On the other hand, non-homogenized milk is more sensitive to oxidation flavour [10, 36]. This fact was observed also in our conditions: in 1983 the occurrence of sunlight flavour of homogenized milk packed in transparent polyethylene sacks increased. After elimination of homogenization this defect almost disappeared [23].

### 2.11 *Packing Material as the Source of Defect Milk Flavour*

One of the functions of the package is to protect consumer milk also against change in flavour. From this aspect it is of great importance to protect milk against adverse effects of light.

For consumer's purposes milk is packed into glass bottles, paper packages and especially plastic packing materials have become frequently used — particularly polyethylene (PE). In the dairy practice the PE packages have been used since the fifties, and they replaced almost completely the classical packing materials.

Clear glass and also transparent PE foil hardly protect milk against defect flavour induced by light. And neither mat PE foil has sufficient protecting effect. Sunlight flavour of milk appears almost within the same time — regardless of using mat PE or clear glass.

The wide-spread PE packages can cause also another type of defect flavour. There is the possibility of migration of the individual PE foil components which can cause its defect flavour separately, or through interaction with some of the milk components. They can also disturb the equilibrium conditions in milk to such a degree that the characteristic flavour is changed to defect one. Also in our department experiments were carried out dealing with these problems (25, 27, 28, 29).

Pavelka and Kadlec [31] considered for the most probable reason of flavour of chemical agents (milk packed into PE foil) the higher values of matting additives in the foils („Rykolen“ and „Remafin“).

Also smell of plastics was found in milk this being suggested to be due to PE foil [26]. Smoke-like flavour of milk was caused by fuming during PE packages shaping used then for milk packing [20].

It results from the numerous studies dealing with the above mentioned problem that the packing material represents the key to protection and keeping the characteristic flavour of milk under the present conditions of its transport, storing, and particularly of sale. From these aspects paper seem to be the most suitable packing material [5].

## Conclusions

It is necessary to emphasize that the defect flavour of milk is not found only in consumer milk, but mostly it is transferred also to milk products.

The problems of defect milk flavour — although having the root in the past — became of greater importance especially in connection with large-scale milk production and its processing in the large capacity dairies — i. e. when the defect milk flavour concerned general consumer public.

Another reason of the topical character of the above mentioned problem consists in improper and even unqualified interferences with the feeding regimen of dairy cows, necessity of increased veterinary care for the health condition of dairy cows, as well as in introduction of extensive mechanization and automation, eventually in increased number of operations during milk production and processing, cleaning, etc. which required also innovation of the technological equipment.

This paper does not deal with all possibilities and reasons of defect milk flavour. However, it is emphasized that the problem is always topical, appearing in the broad spectrum of modifications in the whole field of production, processing and sale of milk.

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### Потенциальные источники дефектного вкуса молока

#### Резюме

Автор наглядно описывает возможности встречаемости различных видов дефектного вкуса молока. Автор работы опирается о литературные данные и о собственный опыт. Схематически изобразил некоторые потенциальные источники дефектного вкуса молока. Особенно подчеркнул неблагоприятное влияние на вкус молока — главным образом на его аромат — влияние лактации, состояния здоровья дойной коровы, кормления, зараженности молока микроорганизмами, негигиеничной дойки, хранения, упаковки — особенно влияние света и теплообработки молока и т. п.

Автор отметил также актуальность проблемы дефектного вкуса молока в мире и у нас, как и необходимость правильной ориентации заинтересованных работников во время ее разработки в наших условиях.

### Potenciálne zdroje defektnej chutnosti mlieka

#### Súhrn

V práci sa prehľadne opisujú možnosti výskytu rôznych druhov defektnej chutnosti mlieka. Čerpalo sa pritom z údajov literatúry a vlastných skúseností autora. Schematicky sa znázornili niektoré potenciálne zdroje defektnej chutnosti mlieka. Osobitne sa zdôraznili nepriaznivé vplyvy na chutnosť mlieka — najmä jeho arómu, napr. vplyv laktácie, zdravotného stavu dojnice, kŕmenie, polutantov, mikrobiálnej kontaminácie mlieka, nehygienického dojenia, skladovania, balenia — najmä vplyv svetla a tepelného ošetrovania mlieka a pod.

Poukázalo sa aj na aktuálnosť problému defektnej chutnosti mlieka vo svete i u nás, ako aj na potrebu správnej orientácie zainteresovaných pracovníkov pri jeho riešení v našich podmienkach.