



OFF-FLAVOURS IN MILK AND MILK PRODUCTS

Oğuz GÜRSOY, Özer KINIK

Ege University, Faculty of Agriculture, Department of Dairy Technology, 35100-Bornova/İzmir

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ABSTRACT

Flavour is the main factor determining the purchase of food and it also effects to consumer preferences. Therefore, flavour problems usually come to light as a result of consumers' complaints, and flavour defects in food are a major cause of consumer rejection of the food product including milk and milk products. Flavour and off-flavour in milk and milk products have been the subject of active research in the last decade; there have been developments in the analytical techniques used to monitor flavour development, flavour and off-flavour compounds in many dairy product have now been investigated. The chemicals responsible for unacceptable flavours in milk and milk products can originate incidental contamination from environmental sources, from animal feeding, from chemical reactions occurring within the food material itself and from other sources. The objectives of this paper comprise, after definitions, summarizing the possible sources and specific compounds of off-flavours, and discussing different approaches for off-flavour concept in milk and dairy products.

Key Words : Flavour, Milk, Milk product, Off-flavour

SÜT VE SÜT ÜRÜNLERİNDE İSTENMEYEN LEZZET

ÖZET

Lezzet gıdanın beğenisini belirleyen başlıca faktördür ve aynı zamanda tüketici tercihlerini de etkilemektedir. Bundan dolayı, lezzet problemleri genellikle tüketici şikayetleri olarak geri dönmektedir ve gıdalardaki lezzet kusurları süt ve süt ürünlerinin de içinde bulunduğu gıdaların tüketiciler tarafından kabul edilmemesinin başlıca nedenidir. Süt ve süt ürünlerinde lezzet ve istenmeyen lezzet son on yılın ilgi çeken araştırma konusu olmuştur; bu bağlamda da lezzet gelişiminin takibi için kullanılan analitik teknikler gelişmiştir ve birçok süt ve süt ürünündeki istenmeyen lezzet bileşikler halen araştırılmaktadır. Süt ve ürünlerindeki istenmeyen lezzete neden olan kimyasallar; çevresel kaynaklardan bulaşma, hayvan beslenmesi, gıda içinde meydana gelen kimyasal reaksiyonlar ve diğer kaynaklar orijini olabilir. Bu makalenin amaçlarını, tanımlamaların ardından, istenmeyen lezzet için muhtemel kaynakların ve kimyasal bileşiklerin özetlenmesi ve süt ve süt ürünlerindeki istenmeyen lezzet kavramı ile ilgili farklı yaklaşımların tartışılması oluşturmaktadır.

Anahtar Kelimeler : Lezzet, Süt, Süt ürünü, İstenmeyen lezzet

1. INTRODUCTION

It has been the goal of flavour researchers in dairy products to be able to describe the important flavour and off-flavour compounds of raw, processed and fermented dairy products, to be able to relate acceptance and quality to these flavour parameters, and to understand the factors governing the

formation of flavour compounds. Off-flavours in dairy foods are a major cause of consumer rejection of the food product, and consequently the occurrence of such flavour defects is of great concern also to the manufacturer.

The flavour of dairy products originates from natural compounds in milk, microbial, enzymic and

chemical transformations and interactions, the relative importance of which is not always fully understood. These transformations give rise to a series of volatile and non-volatile compounds, some of which have been shown to correlate well with some typical flavour notes or flavour defects (Brich, 1989). The chemicals responsible for off-flavours in foods can originate from incidental contamination from environment sources (e.g., water, air, or packaging material) and from chemical reactions occurring within the food material itself (e.g., lipid oxidation, microbial metabolic reactions) (Birch, 1989; Marsili, 1997). In addition, imbalance off-flavours can occur when certain ingredient components that are normally present and often essential to the product are present in abnormally high or low concentrations (Marsili, 1997).

Flavour development in fermented dairy products is a complex and, in the case of cheese ripening, slow process involving chemical and biochemical conversions of milk components. Flavour compounds are formed by various processes, i.e. the conversions of lactose and citrate (glycolysis and pyruvate metabolism), fat (lipolysis), and caseins (proteolysis). Lactic acid bacteria (LAB) form the main microflora in these dairy products, and they are essential for the biochemical conversions that determine the specific flavour. Although lactose is mainly converted to lactate by LAB, a fraction of the intermediate pyruvate can alternatively be converted to various flavour compounds such as diacetyl, acetoin, acetaldehyde, or acetic acid, some of which contribute to typical yoghurt or butter flavours. An important flavour-generating reaction in some dairy products is the conversion of citrate to diacetyl, which can be performed by some LAB strains. Lipolysis results in the formation of free fatty acids, which can be precursors of flavour compounds such as methyl ketones, alcohols, lactones and esters. Lipolysis is mainly due to mould activity, and much less to LAB activity. Fat hydrolysis is particularly important in soft cheeses like Camembert and Blue cheeses. Proteolysis is undoubtedly the most important biochemical process for flavour and texture formation in hard-type and semi-hard-type cheeses. Degradation of caseins by the activities of rennet enzymes, and the cell-envelope proteinase and peptidases from LAB yields small peptides and free amino acids. A good balance between proteolysis and peptidolysis prevents the formation of bitterness in cheese. Although it is known that peptides can taste bitter or delicious and that amino acids can taste sweet, bitter, or broth-like, the direct contribution of peptides and amino acids to flavour is probably limited to a basic taste. Further conversion of amino acids to various alcohols, aldehydes, acids, esters and sulphur compounds is

required for specific flavour development (Van Kranenburg et al., 2002).

One of the most common reasons for consumer rejection of a dairy product is an unacceptable flavour such as mouldy, fruity, mushroom, musty, cooked, rubbery, unclean, harsh, nutty, bitter, cowy, rancid, fishy, soapy, cheesy, catty, faecal, metallic, painty and plastic-like, and every year the dairy industry receives complaints from consumers concerning off-flavours or taints in fresh, processed and packaged products. The chemicals responsible for taints and off-flavours are usually volatile organic compounds, which are frequently found at concentrations of less than $1 \mu\text{g kg}^{-1}$, and cause flavour problems because of their low odour threshold values (Mottram, 1998).

This review will focus on main general sources of off-flavours such as environmental pollutants, animal feeding, proteolysis, microorganisms and micellanaous in milk and milk products, some responsible chemicals in off-flavours and different perspectives about off-flavour concept.

2. ENVIRONMENTAL OFF-FLAVOURS

Over the past four decate, many new synthetic chemicals have been introduced into the environment, and some of these have resulted in the indirect contamination of foods with potent new classes of off-flavours. A lot of chemicals are potential food contaminats through environmental routes. The number of possible off-flavour contaminant targets dwarfs even the number of flavour components (Wilkes et al., 2000). Some environment associated off-flavours are summarized at below.

For fat-soluble pollutants such as polychlorinated biphenyls (PCB) and other clorinated hydrocarbons bioaccumulation can cause flavour defects in dairy products (Dunmot and Adda, 1979; Wilkes et al., 2000).

Ethylbenzene occurs in nature as a fraction of petroleum. It is also an important synthetic chemical that is produced in large quantities as a precursor for styrene and polystyrene. Since traces of residual ethylbenzene might be present in polystyrene, it cannot be excluded that during food contact ethylbenzene may migrate into food from polystyrene packaging material (Tang et al., 2000). Ethylbenzene was detected in milk and dairy

products, especially in cheese (Bosset and Gouch, 1993). The content of ethylbenzene was below the detection limit in fresh high-quality milk, but was about 30 ppb in off-flavoured poor-quality milk (Vallejo-Cordoba and Nakai, 1993). Trace amounts of ethylbenzene were found in some samples of Swiss Emmental cheese. In low-fat dairy products like yoghurts and desserts, contents of ethylbenzene below 4 ppb were reported (Ehret-Henry et al., 1994).

Benzothiazole (Figure 1) has been identified in most dairy products. Its rubbery odour has led to assumption that it came from the rubber of milking machines. An alternative explanation, involving degradation of soil treatment chemicals, should be considered (Dumont and Adda, 1979).

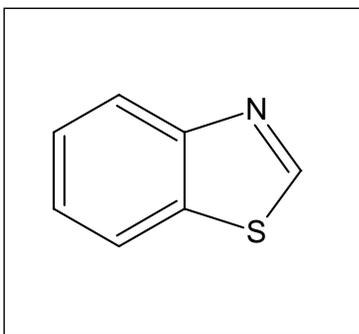


Figure 1. Chemical structure of benzothiazole

Mills et al. (1997) reported that 2-bromo-4-methylphenol (Figure 2) can be responsible for a chemical, phenolic off-flavour in brine-salted Gouda cheese. According to Mottram (1998), it was demonstrated that the probable source of this compound was the attack of active bromine on 4-methylphenol which was present in the brine. The source of bromine was from the action of either U.V. light or sodium hypochlorite on traces of sodium bromine in the brine.

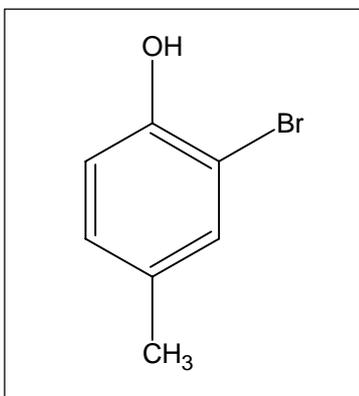


Figure 2. Chemical structure of 2-bromo-4-methylphenol

Milk readily absorbs odors to which it may be exposed. Unclean off-flavours may also be described or referred to as “cowy” or “barny”; they are those objectionable off-flavours that are associated with unsanitary farm conditions. A cowy or barny flavour may be common in areas where cows are housed during the winter months. A cowy flavour is also present in milk from cows with ketosis (a fairly common disease of dairy cattle), a condition in which there are traces of acetone in the milk and body fluids (Lampert, 1975; Bodyfelt et al., 1988).

Another environmental source of off-flavors is containers or packaging materials. Examples include solvent residues from printing inks, lacquers or glues; monomers and other trace constituents from polyethylene, polystyrene, polyvinyl chloride, polypropylene and other plastics used for packaging, and other chemicals from pallets, cardboard and jute sacks (Wilkes et al., 2000).

3. ANIMAL FEEDING-ASSOCIATED OFF-FLAVOURS

Off-flavours derived from the cow’s feed are rather common. The influence of feed on the appearance of a number of off-flavour has been investigated and some interesting flavours have been reported ranging from raspberry to blackcurrant (Marshall, 1984). Generally, some chemical compounds such as dimethyl sulfide, trimethylamine, indole, skatole, benzylmercaptan from different sources may responsible for feed-flavours (Bodyfelt et al., 1988). Dumont and Adda (1979) reported that volatile components of the forage can be transferred to the milk via the rumen and the respiratory tract. Although the transfer is inefficient, many causes of “feed off-flavour” have been reported. According to Marshall (1984), feed associated interesting flavours are a consequence of ketone formation in the rumen, resulting from a shift in microbial metabolism. In addition, feed-flavour may originate with some of the more common feedstuffs, such as ladino clover, corn silage, and grasses such as rye, fescue, and orchard grass. Also brackish water, moss and algae, may give milk with an off-flavour that may be confused with a feed flavour (Lampert, 1975). Although related to feed off-flavours in the manner in which they are transmitted to milk, “weed” off-flavours are generally more serious and require immediate attention. The most common offenders are wild onions, garlic, and related plants, which impart a distinctive “flavour note” that is quite familiar to most people. These weeds grow particularly well during the rainy spring and fall seasons, though in some geographic regions they may be encountered at

almost any time. Weed off-lavours may be encountered in milk, cream, butter, and fermented products (Bodyfelt et al., 1988).

A broad range of phenolic compounds occur in food products, especially those of plant material, in which they contribute to the organoleptic properties, i.e., astringency, beer hazes, specific (dis)coloration and off-flavours such as astringency (Kınık et al., 1996; O'Connell and Fox, 2001). The occurrence of phenolic compounds in milk and dairy products may be a consequence of several factors, e.g., the consumption of particular fodder crops by cattle, the catabolism of proteins by bacteria, contamination with sanitising agents, process-induced incorporation or their deliberate addition as specific flavouring or functional ingredients (Kınık et al., 1996). The consumption of phenolic compound-rich foods by cattle can affect ruminant health and the yield and quality of milk. Indigenous phenolic compounds in milk are not thought to pose a health risk to humans and may have some salutary effects. The specific phenolic compound profile of milks from different ruminant species appear to play a significant role in the distinct sensory traits and the products therefrom. At low levels, phenolic compounds positively contribute to the desirable taste of cheeses but at high levels are responsible for distinct off-flavours and enzyme-catalysed discoloration. The ability of some phenolic compounds to enhance some functional properties of milk and dairy products has also been established, i.e., microbiological stability, foamability, oxidative stability and heat stability (O'Connell and Fox, 2001).

Indigenous phenolic compounds have also been linked to flavour defects in Cheddar cheese and milk (Lemieux and Simard, 1994). The development of a phenolic off-flavour in in-bottle sterilized milk is due to the presence of p-cresol (Figure 3), produced by *Bacillus circulans* (Bading and Neeter, 1980).

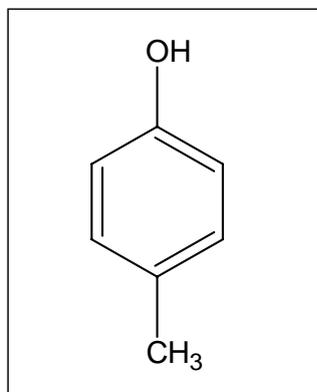


Figure 3. Chemical structure of p-cresol (4-methylphenol)

4. PROTEOLYSIS-ASSOCIATED OFF-FLAVOURS

4. 1. Bitterness

Proteolysis during cheese ripening strongly affects the sensory properties of the cheese (Grappin et al., 1985; Vicente et al., 2001). As well as contributing to desirable flavours, products of proteolysis can cause off-flavours (Davies and Barry, 1984; Schmidt, 1990; Kohlmann et al., 1991; Forde and Fitzgerald, 2000; Mayer, 2001). The most important flavour defects associated proteolysis is bitter flavour or bitterness (Frister et al., 2000). Bitterness in dairy and other foods has been extensively studied and discussed. In general, bitterness in cheese is a flavour defect due to the accumulation of bitter-tasting peptides associated with casein proteolysis caused by the action of proteolytic enzymes derived from milk coagulating agents, starter and non-starter lactic acid bacteria and from the endogenous milk proteinase system (Law; 1987; Mayer, 2001). The type and composition of starter microorganisms can also be important factor in cheese bitterness (Urbach, 1995). Therefore, the most effective methods for bitterness control, involves reduction of total proteolytic activity by culture selection, use of coagulator and adjusting environmental factors (i.e. temperature, pH, etc.) (Rouseff, 1990).

In particular, peptides have been identified as a source of the bitter defect in cheese. Opinions on the size of bitter peptides vary but it is generally agreed that they contain a high proportion of hydrophobic amino acids (e.g., leucine, phenylalanine, proline) (Davies and Barry, 1984; Law, 1987; Rouseff, 1990; Forde and Fitzgerald, 2000). Among the different caseins, α_{s1} -casein produces more bitterness than β -casein. This may be explain why goat and ewe milk cheeses are usually devoid of any bitterness as there is relatively little α_{s1} -casein in goat and ewe milk (Adda, 1986). In addition, it is now well established that lactic acid bacteria contain at least 16 essential peptidases that play a key role in casein degradation and flavour development (Forde and Fitzgerald, 2000).

Bitter peptides from α_{s1} -casein are predominantly from the region of residues 14-34, 91-101 and 143-151, while bitter peptides from β -casein are mostly from the region of residues 46-90, and particularly from the hydrophobic C-terminus. Chymosin (or rennet substitutes) is important in the production of bitter peptides, since residual coagulant is the principal proteinase in many cheese varieties and its primary action on β -casein releases

extremely hydrophobic peptides. Thus factors that affect the retention and activity of coagulant in the curd (e.g., pH or salt) may influence the development of bitterness. Bitter peptides may also be produced directly by starter proteinases and then accumulate in cheese due to the absence of peptidases from starter. "Bitter" starters may be unable to hydrolyse bitter peptides to non-bitter peptides that are too small to be perceived as bitter. Salt may also decrease bitterness by inhibiting lactococcal cell envelope-associated proteinase (CEP) and thereby promote the aggregation of large non-bitter, hydrophobic regions of the caseins (e.g., the C-terminal region of β -casein) and perhaps peptides, which would otherwise be degraded to bitter peptides. The addition of exogenous proteinases, e.g., to accelerate ripening, often causes bitterness, while peptidases have been used to reduce the intensity of bitterness (Sousa et al., 2001).

4. 2. Aldehydes, Alcohols, Keto Acids

Aldehydes, which are occurred from amino acid degradation in cheese ripening, may appear in cheese together with alcohols from amino acids via the Strecker degradation. Amino acids that react with carbonyl compounds can undergo the Strecker degradation in which carbon dioxide is lost from the carboxyl group. These aldehydes are called "Strecker aldehydes" (Hammond, 1989). In Cheddar cheese some of these compounds have been held responsible for "unclean" flavours (Adda, 1986; Hammond, 1989).

Phenylethanol and phenylacetaldehyde give unpleasant flavours, the latter also contributing to an astringent bitterness; 3-methylbutanol, 2-methylbutanol, 2-methylpropanol and methional have been described as giving unclean, harsh and dull flavour, while cresol is held responsible for a typical barley note (Adda, 1986). In Camembert cheese, phenyl acetaldehyde, 2-phenylethanol and the derived ester phenethyl acetate which all result from phenylalanine degradation are identified in fractions with floral rose-like odour (Kubickova and Grosch, 1997). These compounds have been previously assumed to cause the pleasant floral note of Camembert cheese. In contrast, the same degradation products of phenylalanine and some other aromatic amino acid metabolites such as p-cresol, indole and skatole were identified as responsible for unclean-utensil, rose-like off-flavours in Cheddar cheese (Dunn and Lindsay, 1985).

Various chemical degradations of α -keto acids have been reported in cheese. The two main reactions are the conversion of aromatic α -keto acids to aldehydes

with two carbons missing and the conversion of α -ketomethylthiobutyrate to methanethiol. Moreover the α -keto acid derived from tryptophan is very unstable and generates various compounds, which have often been associated with off-flavours in Cheddar cheese (Yvon and Rijnen, 2001).

Indolacetic and hydroxyphenylacetic acids derived from Trp and tyrosinyl respectively can be non-enzymatically or enzymatically degraded to skatole and p-cresol (Figure 3), which are major contributors to off-flavour in Cheddar cheese, and methylthiopropionic acid derived from methionyl might also be subsequently degraded to methanethiol as is the case in a variety of mammals. Indole-3-pyruvate (IPA), is unstable than the other aromatic α -keto acids. It is spontaneously degraded to indole acetic acid, indol-3-aldehyde and skatole, which have been identified as being responsible for off-flavours in Cheddar cheese (Urbach, 1995).

5. MILKFAT-ASSOCIATED OFF-FLAVOURS

Milkfat associated main flavour defects are oxidized and rancid off-flavours. An oxidized off-flavour results from the action of oxygen on certain components of milkfat which produces flavour sensations (Granelli et al., 1998; Walstra et al., 1999) which have been variously described as cardboardy, oily, fishy, painty, and tallowy (Bodyfelt et al., 1988; Walstra et al., 1999). There is a likelihood that these may actually be different off-flavours imparted by different chemical compounds, but they all appear to be the result of auto-oxidation of lipids. A lot of chemicals such as 2-hexenal, 2-heptenal, 2-octenal, 2-nonenal, 2-decenal, 2-undecenal, 2, 4-monodial, 2, 4-dodecadienal may responsible for oxidized off-flavour. The fatty acids are important in the aroma of a lot of cheeses (Dumont and Adda, 1979; Adda, 1986; Hammond, 1989; Walstra et al., 1999). Not only are fatty acids aromatic compounds themselves, but fatty acids also are precursors of methyl ketones, alcohols, lactones and esters. The hydrolysis of fat in cheeses is a phenomenon related to ripening that has been widely described. Unsaturated fatty acids, in the presence of oxygen, form peroxides which decompose into aldehydes and ketones (carbonyls). The reaction is initiated by the catalytic action of certain metals (Cu) and proceeds by a free radical mechanism (Walstra et al., 1999). The carbonyls that are formed contribute to the sensation of the oxidized off-flavour (Bodyfelt et al., 1988). Under certain conditions, triglycerides of milkfat may be partially hydrolyzed as the result of

the catalytic action of lipase, and enzyme indigenous to raw milk. If lipid hydrolysis occurs, free fatty acids are released in product. These low molecular weight fatty acids (carbon length, C₄-C₁₂) may cause an undesirable, soapy, bitter off-flavour, commonly referred to as rancid (Bodyfelt et al., 1988).

6. MICROORGANISMS-ASSOCIATED OFF-FLAVOURS

Numerous flavour defects of dairy products may be caused by bacteria, yeasts, or molds. The most familiar examples in this group are acidic, high acidic, moldy (mildew), yeasty (earthy), musty (swampy), malty, fruity, cheesy (Cheddar like), putrid, rancid, unclean, and bitter taste.

Milk and other dairy products are excellent growth media for many types of psychrotrophic off-flavour microbes, such as *Pseudomonas fluorescens*, *P. fragi*, *P. putida*, *P. sapolactica* and *P. aeruginosa*. These microorganisms may be responsible for some off-flavours such as soapy, apple-like acidity, musty, and rutabaga (swede or turnip) (Çon and Gökalp, 1998; Wilkes et al., 2000). *Pseudomonas fragi* produces ethyl butyrate and ethyl hexanoate in refrigerated milk. Psychrotrophic strains of *Bacillus cereus*, which frequently survive pasteurization and grow in milk at 7 °C, produce a sweet curdling and then a bitter off-flavour. Although selected strains of lactic acid bacteria are necessary for producing many cultured dairy products, other strains spoil them by producing off-flavours. For instance, phenolic off-flavours in cheese may be due to subspecies of *Lactobacillus casei*. In the making of Swiss cheese, correlations have been shown between the abundance of *Enterococcus* spp. in milk and tyramine in cheese; between *L. casei* in milk and histamine in cheese, and between coliforms in milk and diamines in cheese. In cream-filled hazelnut cakes, the osmotolerant spoilage yeast *Hansenula anomala* (= *Pichia anomala*) may produce an off-flavor due to ethyl acetate (Wilkes et al., 2000).

α -Dicarbonyls, particularly methyl-glyoxal and diacetyl, and bacteria which can produce them, appear to play a crucial role in the formation of cheese flavour, both the desirable flavour of full-fat cheese and the meaty-brothy off-flavour of low-fat cheese (Urbach, 1995).

Clostridium tyrobutyricum ferments lactate to butyrate, H₂ and CO₂. Butyrate is responsible for off-flavour formation (Adda, 1986; Beresford et al.,

2001). This can be observed in various types of cheese made from milk contaminated with psychrophilic microflora. Because of this, nitrate (NO₃⁻) is added to the cheese milk as saltpetre (KNO₃) or NaNO₃, in the production of some cheeses such as Edam and Gouda to prevent growth of *Clostridium tyrobutyricum*.

7. ASTRINGENCY

Like bitterness astringency, is a flavour defect liable to affect dairy products. Proteolysis which is one of the important phenomenon in fermented milk products is responsible for astringency in milk and dairy products. Interactions between proteolysis and astringency associated to 2 reason (Kınık et al., 1996):

- a) Amount of hydrolyzed amino groups in peptides
- b) Astringent peptides/bitter peptides and amount of bitter peptides in this ratio

Astringency in dairy products might also originate from different causes: compounds resulting from heat treatment, proteolytically induced peptides and the presence of phenolic compounds (Kınık et al., 1996). Main important astringent materials is presented at below:

- Metallic cation bounds such as aluminium, zinc, copper and calcium.
- Vegetable tannins
- Dehydration agents
- Mineral materials

8. SULPHUR COMPOUNDS

UHT processing involves the heating of milk to a high temperature during a short time in order to obtain a product with a long shelf life at room temperature. Hydrogen sulphide, which is formed in milk upon heating, is responsible for the cooked flavour that is observed in UHT milk (Lampert, 1975; Mehta, 1980; Adda, 1986; Burton, 1994) and sometimes butter (Adda, 1986). In UHT milks, gelation and bitterness are usually related to protein breakdown. In cheese itself sulphur compounds may also be responsible for off-flavours; 4-mercapto-4-methylpentanone-2 has been shown to be responsible for catty off-flavour in Gouda and methanethiol has been shown to give a marked defect to Grana cheese (Adda, 1986).

9. MICELLANAOUS

Soy and rice lecithin were identified as responsible for off-flavours in some cultured dairy products. Soy, rice and hydrogenated soy lecithins were added to milk with lactic acid fermentation to characterize and elucidate formation of volatile off-aromas by Suriyaphan et al. (2001). Sensory panelists detected off-aromas in fermented milk containing unmodified soy or rice lecithin. Instrumental aroma analysis revealed that off-flavour compounds included (E,E)-2,4-nonadienal and (E,Z)- and (E,E)-2,4-decadienal. Formation of 2,4-decadienals occurred within the first 4 h of lactic acid fermentation and reached maximum levels within 14 h of incubation. Enzymatic assays confirmed that washed cells of *Lactococcus* produced H₂O₂. Hydrogenated soy lecithin was suitable to use in cultured dairy products, but use of other soy or rice lecithin resulted in off-flavour formation due to oxidation of polyunsaturated fatty acids (Suriyaphan et al., 2001).

In recent years, researches about fortification of milk and dairy products with some minerals such as calcium and iron and vitamins were increased (Gobling, 1999). Iron fortification of milk and dairy products is also considered as a potential approach to prevent mineral disorders in man. Iron is known to catalyse lipid oxidation resulting in rancidity with development of an unpleasant odour and flavour. The thiobarbituric acid (TBA) test has been extensively applied to raw milk in which the absorbance of TBA reaction products correlates positively with sensory evaluation. Fortification with FeCl₃, FeSO₄ or ferric/ferrous ammonium sulfate causes oxidized off-flavour and high TBA number. To avoid oxidized and metallic flavours and colour changes, different possibilities were described. Sensory evaluation of iron-enriched whole milk shows that ferric iron compounds cause rancid flavour when milk is pasteurized at temperature below 79°C. This off-flavour is acceptable, or completely eliminated simply by pasteurizing at 81°C. Ferrous compounds normally cause definite oxidized flavour when added to raw whole milk before pasteurization. However, deaerating the milk before adding the iron markedly reduces this off-flavour (Gaucheron, 2001).

10. DISCUSSION

Food flavour may become unacceptable due to many reasons. In this paper, some sources of off-flavours in milk and dairy products were summarized. In

discussion part, other important matters from own approaches point of view were discussed.

A lot of dairy products produced in different countries and regions generally possess unique and distinguishing flavour attributes. Consumer attributes and preferences differ from region to region and country to country, so flavour attributes that may be considered undesirable in one region may be favored in a different region. For example, bitterness in Australian and Irish Cheddar cheeses is considered to be desirable, whereas in American Cheddar cheeses this attribute is undesirable (Suriyaphan et al., 2001). Furthermore, in Australia, professional graders regard fruity flavours in some dairy products such as Cheddar cheese as a defect, but these flavours are highly prized by a certain section of the public (Urbach, 1995). Several types of yoghurt have been produced traditionally in Turkey. They are known as Kurut, Torba yoghurt, Tulum and Pestüken. Among these, Torba yoghurt is the most consumed. An other interesting example from off-flavour point of view, in Denizli (the administrative province of Turkey) Torba yoghurt with burned flavour is considered to be desirable, whereas in other region of Turkey burned flavour attribute is undesirable.

Cheese and some other fermented dairy products flavours cannot be produced without starter bacteria. Although adjunct cultures must be selected on the basis of total flavour performance to achieve improved cheese flavour. In recent years, several new probiotic milk and milk products such as especially probiotic cheeses were developed (Godward et al., 2000; Wilkinson et al., 2001). One of the main subjects in mentioned new probiotic products was off-flavours (Gardiner et al., 1998). Thus, culture selection for milk and milk products production is very important.

Flavour of final product is one of the important factors in product development works. Off-flavour compounds must not occur during processing. In addition, interactions between additive materials (food additives) and milk components are extremely important. For example, the development of reduced-fat products such as cheeses frequently involves the replacement of fat with hydrocolloid stabilizers to achieve desirable sensory characteristics. Although such stabilizers may mimic certain characteristics of lipids, studies have shown that hydrocolloid stabilizers can bind or inhibit the release of aroma-active compounds (Rankin and Bodyfelt, 1996; Chen et al., 1999).

Some applications may be suggested for prevention of some off-flavours: The type and intensity of the

feed off-flavour may vary from season to season. Because of this, the availability of feed and forage is also important; moldy or musty feeds should be avoided. The forage should be relatively free from weeds to minimize the occurrence of off-flavours related to rough-age consumption. Preventive measures center around thorough sanitation practices and maintaining a proper storage temperature (<4.4°C) of some milk and dairy products for microorganisms and other sources associated off-flavours. The materials used in packaging of milk and milk products, both raw materials and finished product, are now the main source of off-flavours. Great care is needed to minimize the risk of chemical contamination from materials used in packaging and distribution. However, most off-flavour problems can be avoided by taking relatively simple steps to ensure the control of process.

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