METALLIC CONTAMINATION IN DAIRY INDUSTRY

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Metals

- Milk → any container → usually made up of metals
- Metal container → starts reacting with the metal
- Good quality → milk will remain good
- if not → difficult to maintain the quality of milk

- With respect to flavor, keeping quality and safety of the product → important considerations → '**effect of milk on metals**'

- Metallurgy of the dairy plant is very different

- A slight change in the composition of metal affects → working quality of equipment and wholesomeness of milk and milk products

- Corrosive properties of milk are due to
  - mineral salts in solution
  - protein content

- Solubility of metals in milk and other dairy products is of interest both from the standpoint of
  - durability of the equipment and
  - effect of dissolved metals on the **flavor, keeping quality, and healthfulness** of product

- Aeration favors corrosion and corrosion is greatest at the milk air junction

- Acid milks are more corrosive

Aluminium

- Common single metal, second best to stainless steel
- not appreciably attacked by milk
- strongly corroded by sodium hydroxide and by alkaline solutions
- pure metal is rather soft for use and usually **alloys** are now employed, especially those incorporating **silicon**
- In cleaning aluminium plant and utensils, care must be taken to incorporate a fair proportion of sodium metasilicate in detergent

- Souring of milk and whey also attacks aluminium → cause pitting
- Phosphoric acid used for removing milk-stone on pasteurizing plant → aluminium
- Aluminium is **non-toxic** and no flavor is imparted to milk until **9 ppm** is reached
- **alloys** which appear to be most suitable for use in the dairy industry are those of aluminium with silicon, manganese and magnesium
- Now-a-days it is used in storage tanks, rail tankers, butter churns and cans

Stainless steel (SS)

Mostly all the modern dairies extensively use S.S. because of its

- high resistance to corrosion,
- easy to clean,
- bright,
- good heat conductor,
- gives nice appearance and
- imparts no taints and off flavor to milk and milk products

- S.S. consists of 18 parts of **chromium** and 8 parts of **nickel**
- Addition of **3% molybdenum** further improves the **resistance** of this 18:8 to **corrosive influences**.

The Effects of Metals on Milk and Milk Products

- Passage into milk of any particular metal may have two undesirable consequences in addition to corrosion:

  - may impart a bitter, metallic flavor
  - initiate the cycle of changes leading to oxidized taints

- if **two** metals enter milk to the same extent →effect may be **doubled** or will be very different considering sufficient emphasis upon **flavor** and **keeping quality** of milk-products

- **the effect of metal is of great importance**

- various workers → some of common metals do impart objectionable flavors to milk under certain conditions

- extremely small traces of heavy metals, nickel, manganese, chromium in general and copper in particular exercise a powerful catalytic effect to develop an **oxidative deteriorations**

- these metals find their way into milk through worn coolers in which tinned surface is no longer intact

- Milk is thus in contact with tin and copper at the same time and as a consequence copper dissolves under influence of protein also favor solutions of copper through formation of **cu-protein complex,** which become absorbed by fat globules and in this manner → metal is brought into contact with fat

- Iron, cobalt, nickel, chromium and manganese are also effective, but to a much lesser degree than copper

- Tin and aluminum have little effect

- copper is a normal constituent, being present to the extent of 0.12 ppm but if the concentration rises to 1.5 ppm → **an oily taint** may result.

- Cream, butter and whole milk powder are similarly sensitive to catalytic effect of copper.

- a number of factors affect the degree of action of the metal

- If milk is warm, metal surface is not clean and highly polished (un-cleaned and dull surface), high acidity of milk together with sugar → effect is likely to be **greater**

- Effect of nickel, manganese, chromium and iron are not as severe as those of copper but hastened by acidity

- In addition to its effect on flavor, **fat oxidation** is known to cause → losses of vitamin A and vitamin C

- In case of whole milk powder, concentration of copper as low as 4 ppm has a strong catalytic effect on → oxidation reactions and again this is assisted by presence of moisture

- Fishiness and tallowy flavor defects in butter due to high concentration of acid is further aggravated by metallic contamination.

- Effect of metallic contamination was studied by adding various quantities of metallic lactates during salting of butter

- **Tallowy taint** developed so quickly that no first fishiness could be detected

- possibility of metallic contamination also arises from the metal foil used for capping bottle milk

- Aluminum foil is generally used but when lacquered zinc foil is used → foil is in contact with cream layer → tinned lead allows quantities of lead to pass into milk to a degree → **unsafe** for human consumption

Pasteurized milk

- Milk is brought by vendors in aluminium containers
- In packed form, milk is sold in returnable glass bottles sealed with aluminium foil cap clear glass bottles of 500 ml capacity
- due to handling problems of glass → an alternate packaging system was evolved in early 80's, and thus **plastic pouches** replaced glass bottles

- Plastic pouches are generally made of low-density polyethylene (LDPE film)
- Co-extruded LDPELLDPE film is also used because of its advantage of eliminating pin-hole problems
- The films are of 65-70 µm thick
- Another technological breakthrough in processing and packaging of milk is the **Aseptic Packaging**, commonly known as the Tetra pack milk

- In this packaging system, both
  - **package** and
  - **product** are sterilized separately and the packaging operation is carried out under aseptic (sterile) conditions

- This system offers a **long storage life** of about 3 months, without the need for refrigeration or added preservatives

- A tetra pack carton is formed from a composite material → 5 to 7 layers including paperboard, aluminium foil and polyethylene

Flavored milk

- package should be leak and tamper proof, should have sufficient wet strength and should not pass on any odor or taint to the product packed inside
- The plastic based material used for sachets is octane LLDPE (O-LLDPE)
- OLLDPE when blended with 50% LDPE provides excellent puncture resistance, excellent seal strength and hot tack

- In India, flavored milk drinks are available in

❖ **sterilisable crown cork glass bottles,**
❖ **glass bottles with aluminium foil lid or**
❖ **snap-on plastic lid,**
❖ **plastic sachets and**
❖ **aseptic packs (Tetra bricks)**

- Recently 200ml, **translucent bottles of HDPE with an aluminium foil cap** have also been introduced

Condensed and evaporated milk

- Traditionally, condensed milk was bulk packed in barrels or tinplate containers
- sweetened condensed milk is the most popular out of all other concentrated milks and is packed in conventional food cans with double seam ends
- Evaporated milk is recently packed in aseptic tetrapacks

Butter

- high moisture content → susceptible to **mold growth**

- Flavor and odor are easily affected by
  - absorption from other materials or
  - through spoilage of butter due to oxidative rancidity

- Package → opaque and a high barrier against oxygen and foreign odors

- Most commonly used butter wrap → vegetable parchment paper of 45 gsm

- embossed aluminium foil backed parchment paper has been introduced for UV light protection and sales appeal

- popular packaging style in some countries is to use plastic cups and plastic tubs with lids in different shapes and sizes

- For such applications, PP (Polypropylene) and ABS (Acrylo-Butadiene-Styrene) are widely used

Ghee

- protected from chemical spoilage and rancidity caused by oxygen, light, heat, moisture and metal ions
- major portion of ghee was packed in lacquered or un-lacquered tinplate containers
- alternate packages → plastic based, are now gradually replacing tins
- also marketed in lined cartons with flexible laminated plastics as inner liner materials and in tetrapaks

- In both these packs long shelf-life is achieved
- Laminated pouches of metalized polyester based films are also used
- laminates of polyester, Nylon-6 and use of high barrier materials such as Ethylene Vinyl Alcohol (EVOH) polymer films with a trade name of EVAL can also be explored, as these materials could provide a fairly long shelf-life

Milk powder

- hygroscopic → lumping or caking
- Whole milk powder is highly sensitive to oxygen
- Presence of oxygen causes spoilage of the product due to oxidation and rancidification → packages are required to be vacuum or nitrogen flushed
- bulk packed in 25 kg capacity multiwall paper sacks with plastic liner made of polyethylene
- Alternatively, polyethylene liner can be laminated directly to the inner wall of the paper sack

- flexible materials have evolved through polyethylene bags to **sophisticated multi-ply laminates**

- Stand–up pouches of metalized polyester/LLDPE laminates and polyester/LLDPE laminates are used for **skimmed milk powder**

- **whole milk powder**, a typical structure for a plastic pouch is 12 μ polyester/9 μ Al foil/50 μ PE, and when gas flushed, these pouches are found to be as effective as canning to prolong shelf-life of milk powder

- increasing use of pouches made from co-extruded film of LLDPE–Nylon–LLDPE with gas flushing and laminates of Polyester/Al foil/surlyn/Pd catalyst/surlyn, as oxygen scavenger

Ice-cream

- Conventional form of packages include paperboard cartons, paper cups and in some cases even metal containers

- Various types of packages for ice-cream include:

  - Paper board carton which is poly coated
  - Thermoformed / injection molded plastic containers made from HIPS (high impact polystyrene), PP (Polypropylene) or HDPE (high density polyethylene) → snap on type lids of LDPE (low density polyethylene) or PS (polystyrene)
  - Laminates of BOPP (biaxially oriented polypropylene) or PET (polyethylene terephthalate) are used for candies

Malted Milk Food

- highly sensitive to moisture and is prone to **oxidative changes** in the presence of light, heat and oxygen

- **Aroma retention** of the product and prevention of moisture and oxygen ingress, therefore, is very critical in
- **protecting** the product, and
- in selection of the **right packaging material**

- Types of packages used conventionally → glass jars, tinplate containers → now being replaced by **plastic containers and flexible laminated pouches**

Cheese

- protected against moisture loss and ingress of oxygen in order to maintain desired quality characteristics

- traditional package of cheese is a hermetically sealed printed tin-plate container

- **flexible packaging films and laminates** used for packaging of cheese to provide adequate moisture and oxygen barrier properties and to retain vacuum are:

- Co-extruded LLDPE – TIE – Nylon – TIE – LLDPE
- Co-extruded LLDPE – TIE – EVOH – TIE – LLDPE
- Co-extruded film based on PVDC as the core material
- Laminates of metalized polyester/co-extruded nylon based film

Dahi / Yoghurt

- very short shelf-life at room temperature.
- traditional pack so far was earthenware pot with a loose cover of glassine (a very thin and smooth paper that is air and water resistant) or greaseproof paper
- earthenware pots are very heavy, easily breakable and because of oozing of water from its body, the product inside develops shrinkage cracks
- injection molded polystyrene and polypropylene cups have been introduced with aluminium foil based peelable lids

Traditional dairy products

- Traditionally, indigenous products have been packed in leaves, paper cartons or paper-board boxes
- These materials do not provide sufficient protection to the product from atmospheric contamination and manual handling
- sweets soon lose their typical body and texture, absorb foreign odor and lose their aroma characteristics and show mold growth, when products are stored in open metal trays

- Use of coated films, laminates of aluminium foil with various substrates, metalized films and combinations of various packaging materials need to be tested for suitability for these products

- products like, gulabjamun and rasgolla need protection from light, oxygen, ingress or egress of moisture and micro-organisms

- lacquered tinplate can is the most protective material, but this is very expensive

Milk Capping

- Well-proven method of bottle capping using aluminium foil introduced hygiene and high speed mechanization to milk packaging and contributed to one of the most efficient forms of reused pack

- Used glass bottles are collected and re-filled again and again – so saving valuable material resources

- compatibility of aluminium foil with heat-seal lacquers coupled with the metal's excellent heat conductivity and stability makes it the ideal material for capping and heat-sealing of all types of plastic milk containers

- Whether milk is fresh, aseptically filled or sterilized in the container → foil / coating combination can be designed to meet demands of processing

THANKS