

Packaging Trends of Dairy and Food Products

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ABSTRACT

Packaging is associate indispensable vehicle to deliver merchandise to shoppers. The definition of packaging says that it's a co-ordinated system of insertion food to guard it from change of state or contamination from physical, chemical and biological sources. Currently a days shopper needs food that area unit contemporary, gently preserved, convenient and prepared to serve. Per capita consumption of packaging material in Asian country is four. 3 kg/person/annum and still to be increased. In response to dynamical shopper lifestyles, giant retail teams and food service industries have introduced extremely competitive mixture of selling ways that depends on quality of packaging material and technology utilized. Numerous methodologies of packaging technology for food have developed over the years. New ideas of active packaging, intelligent packaging and engineering science offers innovative solutions that play a vital role for up or monitoring food quality and safety and increasing shelf-life.

INTRODUCTION

Packaging nowadays is Associate in nursing indispensable vehicle to holistically deliver product to shoppers and without packaging, handling would be an untidy, inefficient and expensive exercise, and trendy client promoting would be nearly not possible. Basic Functions of Packaging square measure Containment, Protection, Convenience and Communication [1]. The period of packaged food depends on each the intrinsic nature of food and inessential factors. Intrinsic factors square measure pH scale, water activity, nutrient content, presence of antimicrobial compound and oxidation-reduction potential. Inessential factors square measure storage temporary worker, ratio, encompassing gas composition. Merely Packaging is outlined as intromission food to safeguard it from meddling or contamination from physical, chemical and biological sources [2]. The last word goal of packaging is to reinforce the period of product. Earlier packaging were baskets and baggage made up of plant, leaves, wood boxes. Development and invention of only by one material improved packaging of food and aids in convenient, period of food. For e.g., earlier glass bottles were used however currently replaced by pet bottles, glass- higher weight, possibilities of breakage, transportation issues (**Table 1**).

Table 1. Packaging material used in dairy Industry: overview [3].

Product	Packaging Material
Liquid Milk	Glass Bottles LDPE film in combination with LLDPE Tetra pack, PET pouches and bottles
Milk Powder	Tin containers, nitrogen packed and lacquered Flexible laminates (PET/BOPP/Al foil) Refill Packs Bag-in-box
Butter	Duplex board with vegetable parchment paper, Tinplate container, Al foil
Cheese/ Cheese spread	Tin plate containers lacquered from inside Packed in Al foil and then in duplex carton
Ghee	Tinplate container, Glass bottles, HDPE film pouches
Ice cream	Thermoformed/injection moulded containers, Duplex Board carton, Laminates of BOPP or PET
Indigenous milk products	Injection moulded/thermoformed containers, Stand up Laminate Pouches

Driving Forces for Innovation in Food Packaging Technology

Despite the simplest of barriers, process technologies and controls, foods square measure at risk of organic chemistry and alternative kinds of deterioration and so there's want for applicable packaging technology. Innovation in food packaging

material and packaging technology is ruled by increase in shopper demand for minimally processed foods, amendment in retail and distribution practices, new shopper product provision, new distribution trends (such as net shopping), automatic handling systems at distribution centers (milk ATMs) and tight necessities concerning shopper health and safety [4]. All of those result in development of newer packaging technologies like changed region packaging, active packaging, intelligent packaging and recently Nano packaging.

Recent Trends in Packaging of dairy farm and Food merchandise:

- Controlled atmosphere Packaging
- Modified atmosphere Packaging
- Intelligent Packaging
- Active Packaging

Controlled and Modified Atmosphere Packaging

Modified atmosphere packaging (MAP) is that the replacement of air during a pack with one gas or mixture of gases (mainly carbonic acid gas, N₂ and O₂) whereas controlled atmosphere storage refers to the constant watching and adjustment of gas levels inside gas tight stores or containers. It gives associate degree optimum atmosphere for increasing the storage length and quality of food. Commercially on the market controlled atmosphere systems area unit external gas generator, N part generators, gas apparatus systems, hypobaric storage etc. [5].

The MAP technique has evidenced to be helpful in prolonging the time period of cheese samples in terms of microbiological and sensory aspects. Time period of ready-to-serve pizza pie raised up to forty five days by MAP, compared to standard air pack (15 days) (**Figure 1**) [6].

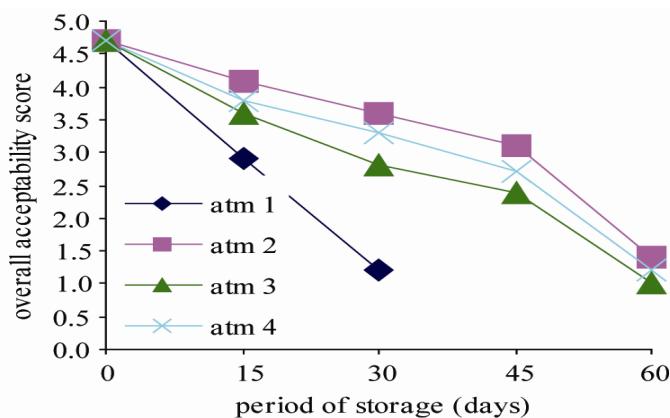


Figure 1. Shelf life study of ready to serve pizza [6].

Most of controlled atmosphere storage techniques area unit appropriate for bulk storage, however sometimes not for retail units [7]. MAP delays the expansion of spoilage and unsought microorganisms and inhibits poisonous substance production in fisheries merchandise [8].

Active Packaging

Active packaging may be an innovative packaging technology that incorporate bound additives into packaging film or inside packaging containers by that package, product, and atmosphere move to prolong time period or enhance safety or sensory properties likewise as maintain the standard of the food [2]. Ahvenainen [9] has given a broad classification of active packaging techniques (**Table 2**).

Table 2. Active packaging techniques.

Absorbing System	Releasing System	Other System
Oxygen absorbers	Carbon dioxide emitters	Self-heating aluminium or steel cans and containers
Carbon dioxide absorbers	Ethanol emitters	Self-cooling aluminium or steel cans and containers
Ethylene absorbers	Antimicrobial releasers	
Ethylene absorbers	Antioxidant releasers	
Absorbers of off flavours		
Lactose remover		
Lactose remover		

Self-cooling Aluminum or Steel Cans and Containers

Oxygen scavenger removes chemical element from within package. Materials like iron incorporated into package structures that with chemicals mix and effectively take away chemical element from the inner package atmosphere. The systems relies on the oxidization of iron and metallic element salts to create stable compound [10]. One gram of associate degree iron can react with three hundred cc of O₂ [11]. varied different materials can even be used as chemical element scavengers like sulfites, boron, light-sensitive dyes and enzymes Classification of chemical element absorbent depends upon activation mechanism (auto activated, water activated and ultraviolet light activated), scavenger form (sachet, label and extrudable component) and reaction speed(fast, medium and slow effect). Commercially on the market chemical element scavenger with marque area unit permanent, Fresilizer, Oxyguard, Zero2, Vitalon, Pure Seal, Bioka and Sanso-cut area unit on the market (in completely different completely different} form of chemical element scavenger and different active substances) (**Figure 2**) [12].

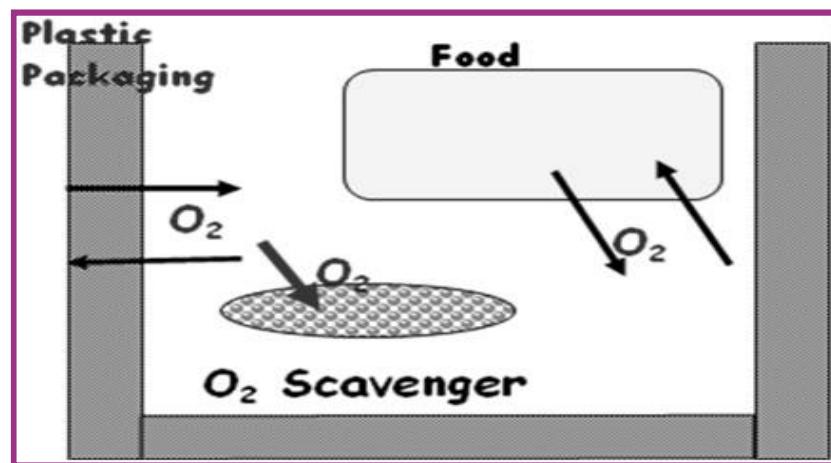


Figure 2. Working principle of oxygen scavenger [13].

Probiotic food superimposed with aldo hexose enzyme maintain low levels of dissolved O₂ and cell viability of *B. longum* and *L. acidophilus* up to twenty first day of storage at cold temperature [14]. Study on UHT milk packaged with chemical element scavenging film shown to reduction in dissolved chemical element content (23% -28%) and off flavor volatiles throughout storage [15]. Associate degree iron-based chemical element absorbent (ABSO2RB) incorporated into the laminate and wont to pack hot-filled paste. It reduces indefinite quantity chemical element concentration by sixty seven. 44% (from twenty 4% to 6.82%) inside twenty four hrs. The time period was half dozen month at 37.8 °C [16]. Vitamin C retention and browning hindrance is done by packaging beverages in PET + chemical element scavenger (**Table 3**) [17].

Oxygen scavenger area unit materials incorporated into package structures that effectively take away chemical element from the inner package atmosphere [13].

Classification by activation mechanism:

- Auto activated systems
- Water activated systems
- UV activated systems

Classification by scavenger form:

- Sachets
- Packaging components
- Extrudable systems

Classification by reaction speed

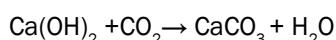
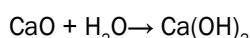
- Fast or at immediate effect (0-1 day)
- Medium or at general effect (1-4 days)
- Slow or at long effect (4-6 days).

Table 3. Various other materials used for oxygen scavenger.

Material	Characteristics
Sulfites	Sodium sulfite and its adjunct palletized powders were placed in a separate sachet. The mix removed 8.5 cc of oxygen in 5 hours ^[18]
Boron	Boron , boric acid, and salts of boric acid Oxygen could be reduced from the 20.9% to <0.1% in three days ^[19]
Unsaturated Fatty Acids And Hydrocarbons	Oleic, linoleic and linolenic, and arachidonic acids. Concentration of O ₂ within a pouch could be reduced to <0.1% within 24 h ^[19]
Enzyme	Glucose Oxidase and catalase ^[20]

CO₂ Scavenger

The carbonic acid gas scavenging bag absorb the occluded carbonic acid gas that otherwise cause the package to burst if not removed throughout storage ^[21]. Carbon dioxide absorbers contain material such as calcium hydroxide, sodium hydroxide, potassium hydroxide, calcium oxide and silica gel. The mechanism is as given below:



It has applications in coffee, battered goods and cheese ^[22].

Ethylene Absorber

Ethylene may be a growth stimulating secretion that accelerates ripening and reduces the time period of fruits and vegetables therefore management of alkene plays a crucial role in prolonging the postharvest lifetime of many varieties of recent manufacture throughout storage.

Alkene scavengers area unit helpful for conserving alkene sensitive fruits and vegetables like apples, bananas, mangoes, tomatoes, onions and carrots. Permanganate of potash is used as alkene absorbent that oxidizes alkene to CO₂ and water. Use of atomic number 6 for alkene surface assimilation and future breakdown by metal catalyst (pelladium) can even be done. Inclusion of finely distributed material like water softener can even absorb alkene in their fine pores and therefore used as a alkene absorbers ^[23]. Active packaging victimization KMnO₄ as alkene absorbent for banana extend the time period to thirty six days at thirteen ± 1 °C ^[24].

Moisture Absorber

In wet sensitive foods, excess wet in packages will have harmful effects like caking in fine merchandise, softening of tender merchandise (crackers) and dampening of absorptive merchandise (sweets and candy) ^[1]. Silica gel, molecular sieves, natural clay, oxide, salt and changed starch will act as wet absorbent ^[4]. Putting humectants between 2 layers of a sheet that is extremely semipermeable to vapor is done to manage excess water. Dominant ratio (RH) victimization hydrophilic salts (such as CaCl₂, MgCl₂) in packaging materials will regulate wet ^[12].

Release or Absorption of Flavours and Odours

Undesirable odours and flavours area unit made because the food material is deescalated. Inclusion of triacetate, acetylated paper, acid, metallic element salt, atomic number 6, clays and zeolites in to packaging material absorbs off flavours and odours ^[25]. They're conjointly incorporated to boost the organoleptic quality of the merchandise. Atomic number 6 bag once placed in package containing tomatoes it showed slowed ripening changes and improved sensory attributes ^[26].

Lactose and steroid alcohol removal beta galactosidase (lactase) is covalently hooked up to surface-functionalized low-density polythene films that act as active packaging materials. It's used for folks affected by hereditary condition and therefore utilized in milk and different dairy farm merchandise ^[27]. Immobilized steroid alcohol enzyme is incorporate in to the packaging material to cut back steroid alcohol ^[9].

ANTIMICROBIAL SYSTEM

Antimicrobial packaging is completed to manage or maybe forestall the expansion of unsought or spoilage microorganisms by emotional antimicrobial substances. Practices like adding a bag containing antimicrobial substance into the package, dispersing bioactive agents within the packaging film, coating bioactive agents on the surface of the packaging material comes below this technique. It works by extending the lag section and reducing the expansion section of microorganisms. Category of antimicrobial compounds includes acid compound, antibiotic, bacteriocin, organic acid, polyose etc. (**Table 4**) ^[28].

Table 4. Potential antimicrobials for food applications [12].

Class	Examples
Acid Anhydride	Benzoic anhydride, Sorbic anhydride
Alcohol	Ethanol
Ammonium Compound	Silicon quaternary ammonium salt
Antibiotic	Natamycin
Antioxidant Phenolic	Grape seed extract, pomegranate peel and seed extracts
Bacteriocin	Bavaricin, Lacticin, Nisin, Pediocin
Chelator	Citric acid, EDTA, Lactoferrin, Polyphosphate
Enzyme	Chitinase, Ethanol oxidase, Glucose oxidase, Lysozyme
Fatty Acid	Lauric acid, Palmitoleic acid
Organic Acid	Acetic acid, Benzoic acid, Citric acid, Lactic acid, Propionic acid, Sorbic acid, Tartaric acid
Plant-Volatile Component	Allylisothiocyanate, Cinnamaldehyde, Eugenol, Terpineol, Thymol
Polysaccharide	Chitosan, Carragenan

Chitosan coating films are tested against bacteria genus in Emmental cheese showed reduction by quite a pair of log units and therefore improvement in storage life is doable. Antimicrobial materials with marque area unit AgIONTM (AgION Technologies LLC, USA), MicroFreeTM (DuPont, USA), Sanitized® (Sanitized Ag/Clariant, Switzerland), Zeomic® (Shinanen New Ceramics Co., Japan), MicroGardTM (Rhone-Poulenc, USA) area unit commercially on the market [29].

Antioxidant Release

Antioxidant compounds scavenge radicals by inhibiting initiation and breaking chain propagation or suppressing formation of free radicals by binding to the metal ions, reducing peroxide, and terminating superoxide and vest chemical element. Compounds like herbs and aromatic plants, natural victuals (vitamin C and vitamin E) and polyphenol area unit used for this purpose [30]. BHA and BHT can even be incorporated into polyolefin films for Dry merchandise [19]. Milk powder with multilayer active packaging film containing α -tocopherol showed delayed super molecule oxidization [31]. Catalyst browning of apple is reduced by incorporation of anti-oxidant agents (cysteine and sulphite) in packaging film [32].

Carbon Dioxide Electrode

In bound food merchandise (fish and shellfish) high carbonic acid gas levels (10-80%) area unit helps in reducing microorganism growth and increasing time period [22]. Such systems area unit supported either metallic element carbonate or a mix of vitamin C and bicarbonate of soda [33]. Commercially on the market carbonic acid gas emitters area unit permanent and FreshPax® by Mitsubishi Gas Chemical Co., Japan [10].

Ethanol Emitter

Ethanol denatures the proteins of molds and yeasts at high concentration and it exhibits antimicrobial effects even at low levels. Alcohol vapor conjointly exert associate degree antistaling impact additionally to its antimold properties. A bag known as Ethicap® generates alcohol vapor and may be used for cakes and breads [34]. Time period of sliced wheat bread unbroken at 20 °C raised up to twenty four days with alcohol electrode [35].

Self-heating and Self-cooling

Self-heating employs metallic element or periclase associate degree water to get an chemical reaction. When rock bottom of will is pushed the salt reacts with water and warmth is made throughout the chemical reaction that heats the merchandise. It's been used for plastic low cans, military rations, and on-the-go meal platters. Self-cooling involves the evaporation of associate degree external compound that removes heat from contents to cool down the drink the lower half is twisted, breaking the seal, resulting in expansion of liquid and its evaporation that reduces the temperature of nutrient to 16 °C [1].

Edible Coating

Edible coatings area unit expendable films which offer supporting structures and protecting layers to food. These films and coatings guarantee the recent look, firmness and shine, therefore adding price to the merchandise [36]. Varied substances appropriate for the event of edible coatings area unit hydrocolloids supported proteins of animal or plant sources (e.g., whey, soy, corn, legumes) or polysaccharides (e.g., polyose derivates, alginates or starches), lipids (e.g., waxes, shellac, fatty acids) or maybe artificial polymers (e.g., polyvinyl acetate) [37]. It is wont to enhance the organic process price of fruits and vegetables by carrying basic nutrients that lack or area unit gift in low amounts. Addition of vitamin C to the alginate edible coating helped to preserve the natural ascorbic acid content in fresh papaya [38]. Edible coating as carriers of antimicrobial compounds is another potential different to reinforce the protection of fresh manufacture. Organic acids, carboxylic acid esters, polypeptides, plant essential oils nitrites, and sulfites is used [39]. Active coating of atomic number 11 alginate with MAP (50% carbonic acid gas and five hundredth N2) is completed to forestall excessive dehydration from the cheese surface and to extend time period up to a hundred and sixty days at 4 °C [40].

INTELLIGENT PACKAGING

Intelligent packaging systems provide info on product quality directly (freshness indicators), regarding package and its indefinite quantity gases (leak indicators), and therefore the storage conditions of the package (time temperature indicator) [34]. Intelligent packaging may well be outlined as a packaging system that's capable of winding up intelligent functions (sensing, detecting, tracing, recording and communicating) to facilitate higher cognitive process to increase time period, improve quality, enhance safety, give info and warn regarding doable issues [41]. A package is intelligent if it's the flexibility to trace the product, sense the atmosphere within or outside the package, and communicate with the patron [42].

Intelligent Packaging Systems

- Indicators
- Time temperature indicator
- Oxygen indicator
- Carbon dioxide indicator
- Colour indicator
- Pathogen indicator
- Freshness indicator
- Leak indicator

Radio Frequency Identification Tags

Sensors

- Bio-Sensors
- Gas sensors [41].

Time temperature indicators (TTIs)

Product safety and quality is affected by variation in temperature and thus its monitoring is needed during storage. TTIs are devices that show an irreversible change in a physical characteristic, usually color or shape, in response to change in preset temperature [43]. They continuously monitor record and indicate the overall influence of temperature history on the product. The response is made to chemical, enzymatic or microbiological changes [44]. Depending upon response mechanism they can be available as partial history and full history indicator. Commercially available TTIs are Monitor MarkTM by 3MTM (diffusion based indicator label), Timestrip® by Timestrip (monitor elapsed time on perishable products), Fresh-Check® by Life Lines (polymer based), Checkpoint® by Vitsab (based on enzymatic system).

Radio frequency identification tags

Radio frequency identification (RFID) may be a system that uses radio waves to trace things wirelessly and provides info concerning quality of product. RFID makes use of tags or transponders (data carriers), readers (receivers), and pc systems (software, hardware, networking, and database) [1].

Working principles:

- Data keep in tags area unit activated by readers once the objects with embedded tags enter the magnetism zone of a reader.
- Data area unit transmitted to a reader for cryptography.
- Decoded information area unit transferred to a {computer system, computing system, automatic data process system, ADP system, ADPS system} for any processing.

Oxygen indicator

These indicators indicate rise or fall in oxygen level based on colour change as a result of a chemical or enzymatic reaction [45]. They are of three types:

- Luminescence-based oxygen indicators
- Colorimetric indicators based on oxygen-binding complexes
- Colorimetric redox dye (such as methylene blue) based indicators

Freshness indicator

It provides indication of the deterioration or loss of freshness of foodstuff by volatile metabolites, like diacetyl, amines,

CO_2 , ammonia and sulphide. Indicators supported color changes as a result of changes in hydrogen ion concentration area unit of nice potential use as indicators [46]. Freshness and fermentation in kimchi (fermented vegetable foods in korea) is monitored by victimization ink consisting of bromocresol purple or methyl group red. Fermentation is assessed by amendment in titratable acidity by amendment in color of indicator [47].

BIOSENSOR

They are compact analytical devices that sight, record and transmit info relating biological reactions. It carries with itbio receptors (such as enzymes, antigens, microbes, hormones and nucleic acids) and transducers (electrochemical, optical, and calorimetric). There area unit 2 biosensor systems commercially on the market

- Poisonous substance Guard by poisonous substance Alert, Canada (antibody primarily based and capable of police work explicit pathogen).
- Food scout System (based on medicine reactions and detects contamination) by SIRA Technologies, California, USA [42].

NANOTECHNOLOGY

Nanotechnology is outlined as control or manipulation of matter at the atomic, molecular, or organic compound level that affects useful behavior. Nano composites area unit main and major invention of engineering science during which nano materials were wont to improve the barrier properties of plastic wrapping for foods and dairy farm merchandise. Detection of chemicals, pathogens, and toxins in foods can even be done by Nano sensors. Nano vesicles are developed to at the same time sight *E. coli* O157:H7, enteric bacteria spp., and *L. monocytogenes*. Nano coating, that is associate degree aqueous-based Nano composite barrier coating, that gives associate degree chemical element barrier with a 1-2 micrometer coating for food packaging use [1].

ECO-FRIENDLY PACKAGING

Eco-friendly packaging can play a key role in food waste avoidance to protect human health, environment and in preserving natural resources. The ideal packaging material should not possess any environmental issues and should have recycling potential. Research in the production of biodegradable packaging material lead to development of eco-friendly packaging materials. Essential qualities for ecofriendly material includes reduce, recycle, renew, reuse and repurpose. They can be material derived from natural resources like starches (such as cellulose, chitin), proteins (such as gluten, soy protein, whey protein) etc. Polylactic acid plastic (PLA) biodegradable thermoplastic derived from lactic acid is currently entering the marketplace. New eco-friendly AJI-NO-MOTO® jar made from sugarcane is also available [48].

CONCLUSION

The idea of ‘package’ as a straightforward instrument for the promoting of food is dynamical to match the requirements of customers and therefore the food business. New varieties of active packaging systems (oxygen scavengers, alkene scavengers, liquid and wet absorbers, flavor and odor absorbers or releasers, antimicrobials, etc.) and intelligent packaging systems (time-temperature indicators, gas detectors, and freshness and/or ripening indicators) area unit developed to cater to special wants. Recognition of the advantages of those technologies by the food business and raised shopper acceptance is important for business realization of those packaging technologies. Eco-friendly packaging materials area unit costlier however offers different for management of environmental problems. Coming back day's area unit guaranteed to witness new trends and innovation in packaging technology.

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