[8]. Freeze-dried food persists longer than other preserved food and due to very lightweight is ideal for space travel. Astronaut John Glenn became the first American to orbit the Earth more than 20 years ago. Glenn's experience helped designing the space food systems, by the first time experimenting eating food in weightless conditions.

By 1970, freeze-drying was commonly used for taxidermy, food preservation, museum conservation, and for pharmaceutical products [9, 16]. In 1980s, companies learned and applied freeze-drying for making long-lasting freeze-dried flowers [17]. In medicine, Altmann used freeze-drying for the preparation of histological sections as early as 1980.

In 2003, Kellogg Company started freeze-drying of strawberries and blueberries for their innovative cereal, "Fruit Harvest Strawberry Blueberry" [18].

Current Scope of Lyophilization

In modern times, lyophilization is widely used in the biotechnology, pharmaceuticals, and biomedical industries for preserving products such as antibiotics macromolecules, electrolytes, proteins, hormones, viruses, vaccines, bacteria, yeasts, blood serum, liposomes, transplant collagen sponge, active drugs. Freeze-drying is used for preserving biological materials like bacterial cultures. Freeze-drying stabilizes them for a long-term storage while minimizing the damages caused by strictly drying the sample. It is observed that many microorganisms survive well after freeze-drying, easily rehydrated, and can be grown in culture media after the long-term storage [19]. Also, many lyophilized products can be supplied easily to different parts of the globe with relatively less concerns of storage conditions. Compared to traditional freeze-drying methods in vials, in recent years, there has been a growth of alternate methods for drying (e.g., spray drying) and more advanced drug delivery devices (e.g., dual-chambered cartridges) containing dried biopharmaceutical products.

History of Lyophilization of Vaccines

The origin of lyophilization of vaccines for mass immunization has a very interesting history. The initial advent of this technology as it relates to current concepts was based on enhanced stability, storage at ambient conditions, shipping at room temperature, ease of administration, and distribution. The first known documented evidence of freeze-drying of a vaccine relates to that of a small pox vaccine in the early nineteenth century [2, 19–24]. Initial efforts to form a "dry powder" by air drying of vaccine components laid the foundation for subsequent advances in dehydration by "freeze-drying." The first freeze-dried formulation for a small pox vaccine was published in 1909 [2, 19–24]. Subsequently, both the bacillus Calmette–Guérin