



# Casein from Spoiled Milk – A Natural Ingredient for Sustainable Bioplastics

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## INTRODUCTION

**B**ioplastics are the alternative source of synthetic plastics with same physical properties, but are mostly biodegradable or compostable under certain conditions. They are derived from renewable sources and can reduce the problem of plastic waste that is suffocating the planet and contaminating the environment. Polyethylene, polypropylene, PVC are the petroleum-based plastics made of fossil fuels commonly used for decades as it is cheap, strong and versatile. However, they come with serious environmental and health problems. Most of the traditional plastics are non-biodegradable and take hundreds of years to degrade. It gradually gets accumulated in landfills, oceans and soils disturbing the wildlife and ecosystems. The presence of Microplastics is now found in the food we eat, the water we drink and the air we breathe. Extracting and processing of fossil fuels to make plastics may lead to depletion of resources and emission of large quantity of greenhouse gases which contribute to climate changes. In addition to this, the additives used in production of plastics leaches into food and water can cause health issues like cancer. Moreover, only a small percentage of plastics are recycled and hence huge amount of plastic daily wastes are accumulated. This urges an alternative for plastics and one such promising alternative source can be spoiled milk. Million litres of milk are wasted every year due to spoilage. Instead of discarding, the spoiled milk can be used for the extraction of casein- the natural milk protein with remarkable functions of plastics. Casein-based bioplastics can be a potential game-changer in the global fight against plastic pollution as it is biodegradable, renewable, and eco-friendly.

### Milk Protein - Casein

Casein is the separable colloidal dispersion of milk produced from skimmed milk. It forms 80 % of the milk protein. Through electrophoretic separation the phosphoprotein casein can be separated into different fractions namely  $\alpha$ -casein,  $\kappa$ -casein,  $\beta$ -casein, and  $\gamma$ -casein each of



which differs in primary, secondary, and tertiary structure, amino acid composition, and molecular weight. Along with amino acids it also consisted of ketones and hydrazine groups. It also associates with calcium to form calcium phosphate salts. Pure casein is amorphous solid with taste and odour while commercial casein is slightly yellow with pleasant odour. Casein when blended with a small amount of clay and formaldehyde, makes its strong by linking the casein protein molecules together. Commercially casein is precipitated from skim milk by gradual addition of diluted acid such as sulfuric acid, hydrochloric or lactic acid to reduce the pH to 4.0. Casein is used in prepared food, medicines, cosmetics and dietary supplements. Major applications of casein include paper coatings, manmade- fibres, glues, paints, plastics etc. Additionally other industrial applications such as seasoning and dressing of leather, cleaners and polishes for shoes, textile printing and sizing, insecticide sprays, soapmaking, and many uses casein as a protective colloid, emulsifying agent, or binder.

### **Preparation of Bioplastics from Milk**

Milk is heated over medium heat in a saucepan until almost boiling, as full boil changes the consistency of casein. Remove the milk from heat and add about four teaspoons of vinegar or lemon juice and stir it well, the milk curdles separating into casein and whey. Strain the casein using cheesecloth. Add baking soda to make the milk plastic pliable by neutralizing the acidity. Knead the mixture to dough like consistency and make it ready for molding. Roll the mixture to different shapes or press it into a mold to create specific shapes. Dry the casein plastic for some days and when hardened, sand down any rough edges and polish it to smooth out imperfections.

### **Applications of Casein Bioplastics**

Bioplastics produced from casein can be used for food packing materials such as wrappers, trays, containers etc. Agricultural tools like biodegradable planters, mulch films, and seedling containers are increasingly being made from casein and dairy waste bioplastics which reduces the environmental footprint of farming practices. The biocompatible nature of these bioplastics makes them suitable for medical applications like sutures, implants, and drug delivery systems which safely break down in the body, negating the need for secondary removal surgery. It is also used as filaments in 3D printers. In textile industries, they are woven into textiles for apparel, upholstery, and other fabric based products.

### **Advantages and limitations of Casein Bioplastics**



Casein bioplastics can be a sustainable alternative for petroleum based plastics. They are nontoxic, biodegradable, renewable and are produced from surplus or spoiled milk. Casein-based plastics can be molded into different shapes. Due to good tensile strength and low flammability, it can be used for packaging, films, coatings, and even medical applications. However, reduced durability and restrict use in humid or wet environments is the main limitations as it is sensitive to moisture. Compared to synthetic plastics, they have relatively poor mechanical strength, limited heat resistance, and higher production costs due to processing requirements.

### **Conclusion**

Casein bioplastics can be a sustainable innovation as biodegradable substitute for petroleum-based plastics. Moreover, their potential to reduce plastic pollution and promote eco-friendly practices is significant. Casein bioplastics can become environment friendly choices in our daily lives through research advancements.

