both finite resources and subject to many price fluctuations. Plastics produced from oil and gas can take many years to break down once their useful life has finished. In addition, the availability and use of landfill waste sites has become less acceptable. Therefore, recent years have seen the development and commercialisation of a wide variety of renewable biopolymers for packaging.

Renewable resources for packaging can be broken down in to four main categories: starch-based, polyhydroxy (alkanoates/butyrates)/polyesters, polylactic acid (PLA) and cellulose-based (See Table 26.4).

In addition to cellulose film (see Section 26.4.3), two of the main renewable packaging materials used for chocolate are PLA and Plantic™.

26.4.6.1 Polylactic Acid

PLA is produced from cereal starch. PLA NatureWorks™ produced by Cargill uses cornstarch and the manufacturing process produces aliphatic polyesters, which can be used for flexible films and rigid packaging. Various trials are currently (2015) being performed using PLA NatureWorks™ for twist wrap applications with chocolate confectionery.

Bi-orientation of PLA films produces properties that include high stiffness, high transparency and gloss, good dead fold and twistability, in addition to printability. The rigidity of the film gives it a metallic sound similar to polystyrene when manipulated that can sound noisy. While PLA can provide good barrier properties to odours and resistance to oils and grease, the barrier to moisture and oxygen is limited.

Supporters of PLA state the material is carbon neutral, coming from carbon-absorbing plants, and therefore reduces the emission of greenhouse gases compared to petro-chemical produced packaging. In addition, when incinerated, PLA will not produce toxic gases. While PLA is compostable, critics state this only applies to industrial composting systems that are continually fed digestive

Table 26.4 Renewable packaging categories.

Category	Manufacturers
Starch-based	Plantic Technologies Ltd
	Biopar (Biop)
	MaterBi (Novamont)
	Bioplast (Biotec)
	IBEK Verpackungs GmbH
Polyhydroxy(alkanoates/butyrates)/polyesters	Biopol, PHA (Metabolix)
	Nodax, PHA (P+G/Kaneka)
	Sorona, polytrimethylene terephthalate (DuPont)
Polylactic acid	NatureWorks
	Hycail
Cellulose-based	NatureFlex (Innovia Films)
	Biograde (FKuR/IBEK Verpackungs GmbH)

microbes at a temperature of 60 °C (140 °F). In addition, opponents claim PLA must not enter the recycling stream of petro-chemical based plastics.

26.4.6.2 Plantic™

Plantic™ is produced from cornstarch which is modified with the inclusion of ingredients such as plasticisers and processing aids and extruded. At the time of writing (2015), the application for chocolate packaging was for vacuum formed trays (VFTs) for chocolate assortment boxes.

Properties of Plantic™ material in VFT format include rigid feel, static resistance, easily heat formable and dissolves completely in warm/hot water. Moisture content control and vacuum forming process control are critical in producing VFTs. In addition, storage conditions of the finished product are important as the material will pick up and lose moisture as the ambient climate changes, which can lead to the material becoming brittle.

26.5 Sustainability

Sustainability has become a major topic and focus area for all food manufacturers and packaging producers. Responsible food producers should ensure all packaging placed on the market is optimised in terms of environmental performance using recognised cradle to grave life cycle analysis (LCA) tools. According to ISO 18602:2013:

> "packaging optimization is the process for the achievement of a minimum adequate weight and volume for meeting the necessary requirements of primary, secondary and transport packaging, when performance and user/consumer acceptability remain unchanged or adequate to reduce the impact of packaging on the environment".

When developed well, packaging makes a valuable contribution to economic, environmental and social sustainability through protecting products, preventing waste and enabling efficient business conduct. Attempts to reduce packaging impacts should only be pursued if they maintain or reduce the overall impacts of the final packed product – a recent study indicated as much as 10 times more energy goes into producing the food contained within the packaging than the actual packaging. Therefore, light-weighting and down-gauging exercises are sustainability meaningless if product waste is increased. To contribute positively to the sustainability of a product, the packaging and product should be designed holistically to optimise the overall environmental performance.

Recycled materials should only be used where there is a clear environmental benefit and where appropriate. For example, much is made of the use of recycled cartonboard; however, there is currently little evidence that the use of recycled board constitutes an environmental advantage due to the lower mechanical properties and potential food safety issues compared to virgin board.