ated with the food dye, amaranth, added specifically to make it appear more intense in colour.

Finished-product considerations

There exists a wide range of typical formulations widely used for plant extracts, which include most of the types used for conventional pharmaceuticals. Most conventional dosage forms can be produced from plant liquid or dried extracts using conventional techniques.

As with conventional pharmaceuticals, solid dosage forms are the preferred type of formulation, while liquids such as syrups are losing favour due to lack of patient acceptability and poor stability during storage. Controlled-release solid dosage forms of plant-based material can also be manufactured.

Preparation of solid dosage forms

Approximately 75% of European herbal medicines are constituted from dry extracts. These dry extracts are invariably hygroscopic. A high porosity excipient, such as microcrystalline cellulose, is usually added to the formulation, together with a cellulose derivative binder. As is the case with conventional tablets (Chapter 30), these extra excipients are responsible for improved physical characteristics of the tablets, notably hardness, friability, and disintegration, when used in the correct proportions for a particular plant extract (Crippa, 1978).

Freeze-dried extracts have been shown to have far greater solubility than powdered plant material, with a direct effect on bioavailability.

Pharmaceutical parameters, such as flowability and hygroscopicity can vary widely depending on the source of the raw plant material. Likewise compactability varies considerably and all these factors may affect tablet/capsule weights and levels of active constituents (Jin et al, 2008).

Preparation of liquid dosage forms

Nearly all types of extracts can be used in formulating liquid dosage forms. If dry extracts are used, the material must be re-dissolved, which may result in precipitation of components or at least the presence of turbidity. To avoid these issues, it is advisable to re-dissolve at precisely the same concentration in the solvent as that which was used to prepare the extract. On some occasions, the downstream processing of the initial extract may modify the composition of the extract so that dissolution does not occur, in which case co-solvents or surfactants may need to be added. The solubility and stability of some extracts can be improved by pH manipulation, particularly when reduction favours salt formation for the active, such as in the case of an alkaloid. The stability of these dosage forms is adversely affected by fermentation, which is prone to occur in extracts containing nutritive plant constituents, but this can be reduced by regulating the alcohol content or by using traditional preservatives, such as *p*-hydroxybenzoic acid esters (Bonati, 1991).

One claimed advantage of plant-based liquid formulations is that they have improved bioavailability, and that unique formulations can be produced for individual patients (Bone, 2003).

Newer delivery systems

Methods used to manufacture liposomes, nanoparticles, phytosomes, emulsions, and microspheres from numerous plant extracts are regularly reported in the scientific literature. Liposomes have been produced for markedly different products including paclitaxel, curcumin, garlic and quercetin.

Herbal medicines are now being formulated and administered via the most up-to-date delivery technologies available. Transferosomes and ethosomes are being used for a range of topical applications. A range of herbal entities have also been formulated into microspheres, as small as 6 μm, which can be ingested or injected and targeted to specific organs of the body (Saraf, 2010).

Excipients

Preservatives. The *p*-hydroxybenzoic acid esters, such as the methyl and propyl esters (parabens), are widely used. However, in a number of formulations such as herbal cosmetics and external medicaments, bronopol is also widely used. The possibility of manufacturing 'organic products' without addition of preservatives has been commercially exploited in a number of herbal products. This strategy normally results in products having a reduced shelf-life.

Antioxidants. The use of antioxidants to limit oxidation in pharmaceuticals and foods are widespread, ascorbate is widely employed for this purpose.

Colouring materials. As concerns about the dangers of artificial colours continues worldwide, plant derived colours are increasingly being used, because their use obviates the use of synthetic dyes. An example is Turmeric from the roots of *Curcuma*