base oils permitted in ambient chocolate are the ones that are most commonly used in CBEs even where these are permitted outside the EU and are:
Illipe, Borneo tallow or Tengkawang (*Shorea* spp.);
Palm oil (*Elaeis guineensis, E. olifera*);
Sal (*Shorea robusta*);
Shea (*Butyrospermum parkii*);
Kokum gurgi (*Garcinia indica*);
Mango kernel(*Mangifera indica*).

The botanical names above are those quoted in the EU regulations (European Union, 2000). There is some controversy over the correct botanical naming of shea because the variety of shea used in confectionery is actually *Vitellaria paradoxa* (Lovett, 2015).

Further restrictions were placed by the EU on the oil in terms of the type of processing which the vegetable fat was allowed to undergo, limiting this to fractionation and refining. Fractionation is a process of crystallisation and separation in which the SOS triglycerides in these oils can be concentrated to a level similar to that found in cocoa butter. This restriction meant that enzymic rearrangement (see Section 7.3.3), which could be used to produce CBEs from oils grown in temperate climates, was specifically excluded. Although only enzymic rearrangement is specifically excluded, other processes, such as hydrogenation, are also excluded because they are not on the permitted list.

Finally, the vegetable fats must be miscible in any proportion with cocoa butter and be compatible with its physical properties (melting point and crystallisation temperatures, melting rate, need for tempering etc.). Essentially these physico-chemical requirements are much the same as many of those in the list of requirements for a CBE given earlier. From a chemical compositional point of view the main requirement for a CBE is that it matches the triglyceride composition of cocoa butter as closely as possible. This means that, ideally, a CBE should contain POP, POSt and StOSt.

#### 7.3.1.1 Palm oil

Palm oil is rich in POP and contributes the greatest part of this triglyceride to the total composition of CBEs. Typical fatty acid and triglyceride compositions of palm oil are shown in Table 7.6.

The triglyceride composition of palm oil in Table 7.6 clearly shows that, while POP is a major triglyceride of palm oil, it is by no means predominant. If, therefore, POP is needed in greater purity in a CBE composition then it needs to be concentrated further in palm oil. This is carried out by the process of fractionation. Historically, this was carried out in an organic solvent such as acetone but, increasingly these days, dry or solvent-free fractionation is used. In either case, fractionation of palm oil is a two-stage process because, as well as the SOS triglycerides (POP and POSt), palm oil contains a significant amount of trisaturated triglycerides (SSS) and of more unsaturated triglycerides containing in

**Table 7.6** Typical fatty acid (Rossell *et al.*, 1983, 1985) and triglyceride compositions (Jurriens, 1968) of palm oil.

| Fatty acid | % | Triglyceride | % |
|---|---|---|---|
| C12:0 | 0.1–0.3 | SSS | 8.5 |
| C14:0 | 0.7–1.3 | MOP | 1.2 |
| C16:0 | 42.6–47.0 | POP | 24.1 |
| C18:0 | 4.0–5.5 | POSt | 7.0 |
| C18:1 | 36.6–39.9 | StOSt | 0.5 |
| C18:2 | 9.5–12.0 | SSO | 5.3 |
| C20:0 | 0.1–0.5 | Two double bonds | 35.0 |
| | | Three double bonds | 19.8 |
| | | >3 double bonds | 0.5 |

total two or more double bonds. The SSS triglycerides are high-melting and, if retained in the CBE, would crystallise out early in the process of tempering chocolate. All that they would do is contribute to increased viscosity and not to improved temper (Smith and Bhaggan, 2014). The more unsaturated triglycerides will simply soften the CBE so both these and SSS need to be removed by fractionation. Palm oil is first fractionated to remove the more unsaturated triglycerides, effectively producing a palm oleine and a palm stearine (rich in SSS and SOS). The stearine is then refractionated to separate out the SSS triglycerides in a "top-fraction" leaving a mid-fraction rich in POP and POSt. This is then used in CBEs.

### 7.3.1.2 Shea oil

Shea is a forest crop indigenous to the sub-Saharan savannah lands of West Africa. It has a long history of use locally and is the fat of choice for baking, frying, skin care in those regions. However, it also has a triglyceride composition that makes it suitable for use in CBEs (as well as being a component of many Western cosmetic products). As has been mentioned earlier, there has been some considerable confusion about the botanical nomenclature of shea oil. In the EU Regulations (European Union, 2000), as well as in the United States FDA GRAS listing and the International Nomenclature of Cosmetic Ingredients, this is defined as *Butyrospermum parkii*. However, after considerable debate amongst botanists it is now agreed that shea belongs to the *Vitellaria* genus (group) and consists of two species or types, *Vitellaria nilotica* and *Vitellaria paradoxa*. The background to this is fully described by Lovett (2015). Of these two types, *Vitellaria paradoxa* is the one used in CBEs.

Typical fatty acid profiles and triglyceride compositions of shea (*Vitellaria paradoxa*) from some of the main West African producing countries are shown in Table 7.7.