

ketones, ethers, furans, phenols, and other nonvolatile compounds. Bio-oil also contains a substantial amount of water. The unstable fragments in bio-oil can rearrange through condensation, cyclization, and polymerization to form new compounds such as aromatics. It is necessary to refine and upgrade bio-oils to transportation fuels by reducing the viscosity, oxygen content, and acidity, removing water, and increasing the heating value and stability (Zhang et al., 2007).

#### 14.4.6 CONVERSION OF USED COOKING OIL AND ANIMAL FATS INTO BIODIESEL

Biodiesel is currently produced from food-grade vegetable oils such as soybean oil in the United States and rapeseed in Europe. Since food-grade vegetable oils are expensive, biodiesel produced from food-grade vegetable oil is not economically feasible. Animal fats, waste cooking oils, and restaurant grease are potential feedstocks for biodiesel production.

The food processing industry generates a large amount of waste cooking oils and animal fats. The production of inexpensive nonedible feedstocks including grease and animal fats as shown in Table 14.6 represents one-third of the US total oil and fat production (Canakci, 2007). In France, fatty residues from both plants and animals represent an overall production of 0.55 million tons/year. The food industry generates 29% of the total fatty residues. The catering industry, wastewater treatment plants, and autonomous sanitation have shares of about 32%, 23%, and 16%, respectively (Mounicimne et al., 2003).

Grease is produced from vegetable oils or animal fats that are heated and used for cooking food products. Yellow grease is required to have a free fatty acid (FFA) level of less than 15%. Brown grease or trap grease has an FFA level higher than 15%. The price of yellow grease varied widely from \$0.09 to \$0.20/lb in 2000, compared to \$0.35/lb for soybean oil. Brown grease is usually discounted \$0.01–\$0.03/lb below the price of yellow grease. Brown grease is often considered as a potential feedstock for biodiesel production because of its low price (Canakci, 2007). Animal fats are mainly from meat processing facilities. Another source of animal fats is the collection and processing of animal mortalities by rendering companies.

One pound of most fats and oils can be converted to a pound of biodiesel. If all of the 5.284 million tons/year of greases and animal fats in the United States were converted to biodiesel, it would replace about 1.5 billion gallons of diesel fuel (Canakci, 2007). Research showed that the content of FFAs in nonedible oils and fats varied from 0.7% to 41.8% and moisture content from 0.01% to 55.38% (Canakci, 2007). The FFAs and water contents have significant effects on the transesterification of nonedible oils and fats (glycerides) with alcohols using alkaline in a traditional biodiesel production process. They also interfere with the separation of fatty acid esters and glycerol.

**TABLE 14.6**  
**Average Production Capacity of**  
**Nonedible Oils and Fats in the**  
**United States between 1995 and 2000**

Animal Fats and Grease	Amount (Million Tons)
Tallow	2.489
Yellow grease	1.195
Lard and grease	0.593
Poultry fat	1.006
Total	5.284

Source: Canakci, M., *Bioresour. Technol.*, 98, 183, 2007.